DIETETICS

OR

FOOD IN HEALTH & DISEASE

WILLIAM TIBBLES

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The Lancet.—" Books on foods are numerous enough, but we do not recall a work which sets out a comprehensive account of so many foods and beverages as does the one before us. The author has evidently taken considerable pains to collect from a mass of materials, spread over scientific journals, textbooks, official publications, periodical literature, and so forth, the facts connected with the origin, composition, and manufacture of dietetic substances, and he is entitled to the gratitude of all interested, directly and indirectly, in the subject for bringing such useful information together within the boundaries of a single volume."

Edinburgh Medical Journal.—" Although this book deals with an aspect of the subject of food which does not so closely touch a doctor's work as does dietetics, the information contained in it will prove of interest to practitioners as well as to the public health officials for whom it is more especially intended. We regard Dr. Tibbles' book among the best and most comprehensive authorities on its subject."

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BY

WILLIAM TIBBLES

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LONDON
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1914

PREFACE

In this volume, dealing with food in health and disease, the theory and principles of dietetics are applied to the many conditions and circumstances of life, and, with my previous work on "Foods: their Origin, Composition, and Manufacture," it forms a complete system of dietetics.

Dietetics and the application of its principles has been my special study for many years, and the more I learn of the subject, the greater importance it assumes in my estimation. In fact, I deem it of such importance to mankind that I would there were appointed a Professor of Dietetics in every University and Medical College throughout the world, and that this subject should be given the same prominence in the curriculum of the medical student which is given to materia medica and therapeutics. In all colleges of agriculture prominence is given to the study of animal and plant foods. If such knowledge is deemed of importance to the breeder of animals and the grower of grain or fruit, surely it is no less so to the physician who has the care of the human body. Indeed, I have no hesitation in saying that the study of dietetics and its practical application would benefit 50 per cent. of the physicians' clients when they are sick, and is no less important as a branch of preventative medicine.

Life consists of a series of changes in the protoplasm—the birth, growth, and death of cells following each other in an interminable cycle. But the processes of life can only go on in a normal manner when the cells are supplied with a well-balanced food, suitable for their needs. This demands a supply of protein, fat, and carbohydrate in due proportions. A study of the composition of foods shows the absurdity of fads; it also shows that all the elements can be derived equally well from the animal or vegetable kingdoms, so that the poorest individual may be well fed if the principles of dietetics are properly applied.

But no sooner has the isodynamical law of foods received general

acceptance, than doubt is thrown on its universal application. The question whether all proteins are of the same value to the body has recently been debated and investigated. To enable each cell in the body to maintain its edifice according to its architectural plan, it must be supplied with building-stones of a proper pattern. These building-stones are amino-acids. All proteins contain them, but the kinds and proportions are not always the same. It has been shown by biological experiments that life and growth cannot be maintained when certain amino-acids are deficient.

It has long been known that life cannot be supported on a diet which is deficient in inorganic salts. But less is known of the rôle of the salts in the body than of the primary elements of the food. "The balance of acid and basic group, the changing need for individual elements like phosphorus, calcium, chlorine, and iron, furnish a series of complex variables which are probably as indispensable to certain aspects of nutrition as they are unappreciated."

But it has been found that something more is essential for the maintenance of growth and well-being than protein, fat, carbohydrates, and salts; that foods contain a minute proportion of accessory bodies, and when these are deficient or absent from the diet, the immature body does not grow, the mature body does not maintain its condition, and there are manifestations of more or less serious disease. A considerable amount of research into the nature of the group of accessory bodies, which have been called "vitamines," has been made. It has long been known that certain foods have a greater growth-producing power than others; that fresh milk prevents scurvy and rickets, and boiled or condensed milk cause these diseases; that oatmeal causes more rapid and greater growth than bread, and wholemeal bread than white bread; that beri-beri, pellagra, and other diseases are associated with the consumption of certain foods. The reasons have not been clear, but considerable light has been thrown on these matters by the recent investigation of the vitamines. So important are the vitamines that they are now regarded as a *sine qua non* of proper nutrition, and the subject is so far-reaching that it involves a large proportion of the foods of civilized man.

The phosphorus-deficiency theory of the cause of certain groups of diseases brings into prominence the importance of the lipoidal constituents of the diet and the rôle these substances play in the life and metabolism of the cells, which, again, is not separated from the rôle of the salts.

The study by many men of the enzymes and their striking specificity, of the lipoids by Overton and Meyer, of the salts by Lillie and Loeb, of the insufficiency of certain proteins by Osborne and Mendel, of the vitamines by Casimir Funk and others during the last few years is epoch-making, and has caused a corresponding advance in dietetics. These discoveries are so important as to raise the question whether nutritive failure or success does not depend as much on the accessory bodies—the vitamines, enzymes, and lipoids—as on the primary elements of the diet. An attempt is made in this volume to give an account of the most recent researches in these subjects, and to place the results in a proper light.

It is hoped that this book, while satisfying the need of the practical physician, may stimulate further research, and that the physician himself may be induced to make observations on the effects of various kinds of foods in those whose metabolism is disturbed by disease, as well as in those whose physiological and metabolical processes are normal.

WILLIAM TIBBLES.

NOTTINGHAM, ENGLAND,
May, 1914.

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DIETETICS

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PART I

INTRODUCTION

THE stock from which primitive man was evolved fed on fruit, nuts, roots, eggs, birds, and insects. The Asiatic stock became shepherds, domesticated several species of animals, and the more settled tribes began the cultivation of cereals in the alluvial plains of great rivers. The arts of domestication and cultivation were gradually diffused over a wide region of the earth. According to Cæsar, Strabo, Diodorus Siculus, and other ancient writers, the British aborigines did not cultivate the ground, but lived on fish, flesh, milk, and the herbs of the field. The Danish kitchen middens show that their Continental neighbours also were consumers of flesh and fish. The common ox was domesticated from ancestors which cannot now be traced; but the present species in Europe are descended from cattle diffused by the Romans, and were probably derived from Egyptian or Indian cattle. Domestic sheep were probably derived from wild animals in Africa, Greece, and Central Asia, the pig from ancestors which inhabited the forests of Europe, Africa, and Asia. The date of cultivation of the cereals cannot be discovered with certainty. Wheat was cultivated in Egypt before the Shepherd Kings; it was found enclosed in a brick of the Pyramids, to which the date 3359 B.C. has been given. But it was probably first cultivated at an earlier date in the valley of the Euphrates. The Chinese date the art of bread-making from about 2000 B.C., but bread was in use among the Chaldeans and Egyptians before that date. The cultivation of rice in China dates from 2800 B.C., and in British India at least from the Aryan invasion. The Greeks became acquainted with it through Alexander's expedition (334 B.C.). The Arabs introduced it into Spain, and the Spaniards into America. Rye is not so ancient: it has not been found in Egyptian monuments; the Greeks did not know it, nor did the lake-dwellers of Switzerland in the Bronze Age; it probably had its origin along the banks of the Danube. Oats have been cultivated for 2,000 years in Europe. They were known to the Greeks, but the Egyptians did not cultivate them. Barley was

cultivated in Switzerland and Italy before the lake-dwellers possessed metals, and some varieties have been found in Greece and Egypt. Indian corn was cultivated in America before it was discovered by Columbus, and undoubtedly it was a product of the ancient inhabitants of Peru and Mexico. Millet was cultivated in Asia and Africa in prehistoric times. There is evidence of its cultivation in China in 2800 B.C., and that it spread westward through Russia and Austria until it reached Switzerland and Italy in the Stone Age. Some forms of millet were cultivated in Egypt at an equally early period, and became known to the ancient Greeks and Romans. Indian millet, or durra, has been cultivated in Egypt for 4,000 years, and is believed to have had its origin in Africa, and spread thence to India and China.

The potato originated in Chili, and its cultivation in North America and Europe began after the discovery of America by Columbus. The garden pea was brought into Greece and Italy by the Aryans from Western Asia. Beans were also first cultivated by the Aryans, and introduced by them into Europe; but the haricot, frijole, and Lima beans originated in South America. The cultivation of lentils in Egypt and Chaldea was begun before all history, but they grew wild in Greece and Italy before they were cultivated there. Many of our vegetables grew wild in Europe long before they were cultivated. The cauliflower was known to the Greeks and Romans. The cabbage was cultivated before the Aryan invasion. Spinach was cultivated by the Medes and Persians; it was common at Nineveh and Babylon. The cultivation of onions appears to have originated in India, but they were known to the ancient Egyptians, and probably came from India through Egypt to Greece.

The cultivation of fruit is probably not so ancient as that of the cereals. Grapes grew wild in Southern Europe, but their cultivation was introduced by the Phœnicians. Records of wine-making go back 5,000 to 6,000 years. Apples and pears grew wild in Britain, but their cultivation was introduced by the Romans. The sweet orange came from China, where its cultivation is prehistoric; the citron from Western Asia, where it was cultivated by the Medes. The lemon was brought into Europe from the gardens of Egypt and Palestine. Pineapples first came from South America; bananas from Southern Asia, where they were found at the time of Alexander's expedition; but it is probable that they were first cultivated in the Malay Archipelago.

The irruption of the Aryans into Europe was the means of introducing the cultivation of cereals and increasing the domestication of animals, and in consequence the European diet became mixed. The overgrowth of population in Eastern Asia caused the consumption of rice, through the lack of animal food. To this day the Arab lives on his original diet of fruit, nuts, eggs, birds, etc.; and the Esquimau remains an example of the flesh-eater. Great has been the influence of man upon his diet. Very few of our foods are now used in their natural condition. The art of gastronomy, or

science of good living, affected by the epicure, has had an appreciable effect upon the development and refinement of materials for the table. The art of cookery, fostered by the desires of people, has developed the methods of preparing foods in such a way as to be agreeable to the palate, pleasant to the eye, and attractive by their general utility. This volume has nothing to do with gastronomy or cookery; it is confined to dietetics. Dietetics is the science of feeding. It has to deal with the necessities of the body and the ability of food to supply those necessities in the various circumstances and conditions of life. It is based upon a very broad foundation of chemistry and physiology. It is an inductive science, and therefore the base must be firm and well established. Experience is a good guide in many sciences, as well as in every department of human life. But experience alone is not sufficient to establish the necessity or desirability for any special course of action. This has been well exemplified in dietetics. The endeavour to understand dietetics without the assistance of chemistry and physiology would be futile.

Food Values.—Food is required for growth and repair—that is, to build up the organism and make good the losses sustained by physiological processes; to maintain the heat of the organism and supply it with mechanical energy. Foods contain a varying proportion of chemical constituents belonging to the groups of proteins, fats, carbohydrates, mineral salts, and water. The body is composed of materials belonging to the same groups.

The **proteins** include—

1. **Protamins.**
2. **Histons.**
3. **Albumins**—egg-albumin, serum-albumin, milk-albumin, muscle-albumin, and cell-albumin.
4. **Globulins**—serum-globulin, myo-globulin, myosinogen, fibrinogen.
5. **Glutelins**—legumin, conglutin, etc.
6. **Gliadins**—wheat-gliadin, hordein, zein, etc.
7. **Scleroproteins**—gelatin, chondrin, collagen, keratin, elastin, chitin.
8. **Phosphoproteins**—ovo-vitellin, casinogen.
9. **Conjugated Proteins:**
   (*a*) *Nucleo-proteins*—*e.g.*, nucleo-histon, leuco-nuclein, cyto-globin.
   (*b*) *Gluco-proteins*—*e.g.*, mucin, euglobin.
   (*c*) *Chromo-proteins*—*e.g.*, hæmoglobin.
10. **Derivatives of Protein:**
   (*a*) *Metaproteins*—acid-albumin, alkali-albumin, etc.
   (*b*) *Proteoses*—albumose, globulose, gelatose, caseinose, etc.
   (*c*) *Peptones*—albumin-peptone, gelatin-peptone.
   (*d*) *Polypeptides*—glycyl-glycin, alanyl-alanin.

In addition to proteins there are the *nitrogenous extractives*—

(*a*) **Nuclein bases or purin bodies** — hypoxanthin, xanthin, uric acid, adenin, guanin, carnin, keteroxanthin, theophyllin, theobromin, and caffein.

(*b*) **Guanadin bases**—creatin and creatinin.

(*c*) **Amides and amino-acids**—leucin, asparagin, glutaminic acid, etc.

Proteins form the principal part of muscles, bones, and many other tissues of animal bodies; they also constitute some of the most important vegetable structures. As a source of nutriment to mankind they are exceedingly important. They are most abundant in animal foods, such as lean meat, fish, fowl, milk, cheese, and eggs; but all legumes and nuts contain a considerable proportion of proteins, and they are present in grain. Proteins are of value to the human body as tissue-formers, and secondly as producers of energy, being equal in the latter respect to carbohydrates. The extractives are not tissue-formers as a rule. The purin and guanadin bases yield little energy, but they have a food value as flavouring agents, render our food appetizing, and to some extent are stimulants. The palatability of meat and soup is due to their presence. The exact food value of the amides is not known; they are used in the constructive processes of plants, being directly converted into globulins and other proteins. In the animal economy they do not appear to be directly used in tissue formation, and are considered to have an inferior food value. But asparagin is a stimulant to cell activity, and it activates various enzymes, whence it may be deduced that the presence of amides in our food is not valueless, and should not be disregarded. The amino-acids may be directly utilized in protein formation, and they have a decided heat value.

The **fats** consist of neutral fats of the fatty acids: stearin, olein, and palmitin. Many fatty substances contain small proportions of free acids: stearic, oleic, palmitic, capric, caprylic, caproic, and butyric acids. These substances are widely distributed through the animal and vegetable kingdoms. Fat is essential in the food of mankind; it is absorbed ready-formed from the food, or manufactured in the body from proteins and carbohydrates. Neutral fats and fatty acids are valuable foods, but serve chiefly as a source of heat and mechanical energy. Besides these, there are various nitrogenous fats, called **lipoids,** including lecithins and cholesterins. Lecithins are widely distributed; they are constituents of every animal and vegetable cell, but are especially abundant in brains, yolk of eggs, fish-roe, blood, bile, yeast, maize, peas, beans, wheat, and beetroot. Cholesterin is also constantly present in animal and vegetable cells; it is abundant in bile, blood, yolk of eggs, spleen, nerve tissues, wool-fat; it is also present in wheat, barley, peas, beans, lentils, carrots, beetroot, almonds, peanuts, etc. The exact rôle played by these substances in the vital functions is not settled. But they are indispensable to man, and a constant supply is essential to the organism.

The **carbohydrates** are chiefly as follows:

1. **Monosaccharides:**
   Pentoses—arabinose, xylose, ribose, and rhamnose.
   Hexoses—dextrose, levulose, galactose, mannose, sorbinose, etc.
2. **Disaccharides**—saccharose, maltose, lactose.
3. **Trisaccharides**—raffinose or melitose, stachyose.

4. **Polysaccharides :**
   Amyloses—starch, inulin, glycogen.
   Mucilages—dextrin, gums.
   Celluloses—true cellulose, hemicellulose.
   Pectose bodies.

Carbohydrates are chiefly of value to the animal organism for the production of heat and muscular energy. When the metabolism is perfect, any carbohydrate consumed in excess of the ordinary requirement is converted into glycogen and fat, and stored for providing heat and energy at a future date. Carbohydrates are essential to the well-being of the organism; reduction of the intake below the essential point frequently leads to acetonuria. Most carbohydrates are of vegetable origin, but a few of them arise in the animal kingdom—*e.g.*, glycogen, lactose, galactose, inosite, glucosamine, and some glucosides. Various proteins contain carbohydrate in their molecular structure, especially gluco-proteins; and many chemists hold the opinion that most proteins have a carbohydrate nucleus in their complex composition.

The **mineral substances** form 5 or 6 per cent. by weight of the human body, and are constantly leaving it by various channels. They yield very little heat or energy, but they serve good purposes in the body, and are indispensable elements of the food. They give solidity and stability to the organism by constituting a considerable proportion of the bones. They keep various proteins in solution, and confer upon them the property of electrical conductivity. They are necessary for all the secretions, and assist in the general metabolism. The carbonates of soda, potash, iron, and other minerals, render our blood and secretions alkaline. The removal of carbon dioxide is performed chiefly by the alkaline carbonates, which take it from the blood and surrender it to the air in the lungs. The phosphates of lime, magnesia, soda, and potash, enter into the composition of bone, other tissues, and secretions; and organic compounds of phosphorus enter into the composition of brain, nerves, muscles, blood, and the nuclei of cells. Sulphur and its compounds enter into the composition of many tissues in the body and some of the secretions. Sulphates of soda, potash, lime, magnesia, and manganese, occur in many foods. Chlorine is required for all human structures and secretions. The need for chloride of sodium is great; it enters the system with many foods, is readily absorbed, and easily leaves it. Its presence promotes metabolism. The total daily requirement of salts is estimated at about 360 grains. They consist of calcium, sodium, potassium, magnesium, manganese, and iron, in combination with carbonic, sulphuric, phosphoric, and silicic acids, chlorine and fluorine. Many organic acids are taken in with our food: they are chiefly acetic, citric, malic, oxalic, and tartaric acids; and citrates, acetates, oxalates, malates, and tartrates. These are mostly transformed into alkaline carbonates in their course through the system, and usefully increase the alkalinity of the blood and secretions.

Water is quite as important for the animal body as other foods. Without it the elements could not be combined into an organism, nor could the organism carry out its physiological functions. It forms 58·5 per cent. by weight of the human body. The daily requirement is estimated from the average loss by the skin, lungs, and kidneys, which excrete a total of about 80 ounces a day. This loss has to be made good by food and drink.

It has become an established custom to compare the human body to a machine. A machine derives its power from fuel; the body does the same. In both instances the potential energy of the fuel is transformed into the kinetic energy or mechanical power which works the machine. In both cases the energy which is not used in work escapes in the form of heat. The human body uses the mechanical power chiefly in muscular work; the heat is used in warming the body and causing the evaporation of moisture from its surface. There are, of course, material differences between the human body and a mechanical engine. The engine has to be made, repaired, fed, and regulated. The human machine grows, it repairs itself, feeds and regulates itself. The material and energy of the human machine is derived from the food; and as its tissues are made out of the food, so can those tissues be used for fuel. The engine can neither repair itself nor consume its own substance. The animal organism is much superior to the mechanical engine. It is more economical in the use of fuel; it has a nervous organization rendering it sensible to impressions and capable of directing its energies. The human machine is capable of adapting itself to many circumstances and changes in the demands made upon it. But to enable the body to continue to perform these functions indefinitely it must be properly fed; and the proper feeding of the body requires a knowledge of its composition and the exchanges which are constantly going on. This knowledge is to be derived from the study of metabolism, the analysis of foods, and a determination of their heat value. Proteins, fats, and carbohydrates, all yield heat and energy; but proteins alone are capable of being transformed into muscle and other living cells, whence they are called "flesh-formers." The albumins, globulins, and their derivatives, are alone capable of being built up into the cells of muscles, tendon, cartilage, bone, skin, and blood. The scleroproteins or gelatinoids, dissolved out of gristle, tendon, and bone, by boiling, are similar to albumins and globulins, and it is believed they are not flesh-formers. But they are admirable protein-sparers; that is to say, when the food contains an abundance of gelatinoid substances in a digestible form, a smaller quantity of proteins is required by the body. This explains fully the value of soup made from bones, gristle, and other nitrogenous materials of a like character, as well as gelatin and its preparations. Fats and carbohydrates are not tissue-formers; their primary function is to supply the body with fuel or heat and energy. Although the various groups

of foods are not equally useful to the body, they all serve as a source of heat and energy.

The value of any food as a source of heat and energy can be determined in several ways. The most important method is by ascertaining the amount of heat developed during the combustion of a known quantity of the food in question. This can be done by using a bomb-calorimeter. The heat given off during the combustion is a measure of the latent or potential energy of the food. The kinetic energy of the food is the amount of heat developed by the proportion which is digested. This matter will be dealt with more fully in the text. The unit commonly used is the calorie, or amount of heat which would be required to raise the temperature of 1 kilogramme of water 1° C. The calorie is about equal to the amount of heat required to raise the temperature of 1 pound of water 4° F. The older observers, instead of the calorie, used the foot-ton as a unit, and this represented the force required to raise 1 ton weight through 1 foot of height. A calorie is equal to 1·54 foot-tons; in other words, a calorie of heat, when transformed to mechanical energy, would raise 1 ton 1·54 feet.

Food values may also be calculated from well-known factors. Thus, it has been determined that 1 gramme of protein or carbohydrate yields in the body 4·1 calories; 1 gramme of fat, 9·3 calories; and 1 gramme of alcohol, 7 calories. Therefore, when 100 grammes of milk contain 3·5 grammes of protein, 4 grammes of fat, and 5 grammes of carbohydrate, the heat value of the milk is $(3{\cdot}5 + 5{\cdot}0) \times 4{\cdot}1 + (4{\cdot}0 \times 9{\cdot}3) = 72$ calories. This method shows that 1 pound of milk might be expected to yield 320 calories; the amount it actually yields in a bomb-calorimeter during combustion is 325 calories, which proves that calculation of the calorie value by factors is sufficiently reliable for clinical purposes.

The food value may also be calculated by using the formula—Protein : Fat : Carbohydrate : : 5 : 3 : 1; but this is only reliable when the digestibility of the constituents of the food is known. It may be accepted that in animal foods 97 per cent. of the protein, 95 per cent. of fat, and 98 per cent. of carbohydrate, is digestible; in vegetable foods, generally 84 per cent. of the protein, 90 per cent. of fats, and 95 per cent. of carbohydrates, is digestible; in cereal foods 85 per cent. of proteins, but in leguminous foods only 78 per cent. of proteins, is digestible. Water may be reckoned as having a food value of 1 per 1,000, and this figure may be added to the nutrients in barley-water and similar infusions. With these figures before us, when the percentage composition of any food is known, we can calculate the calorie value and food value of any substance. The following examples of food values may be useful:

Roast beef: 1,000 grammes contain—

Protein ..	222 grammes gross, equal to	215 grammes digestible.
Fat ..	285 ,, ,,	275 ,, ,,

∴ Food value is $(215 \times 5) + (270 \times 3) = 1{,}868$.

Bread: 1,000 grammes contain—

Protein	77 grammes gross, equal to	64·68 grammes digestible.
Fat	9 " "	8·10 " "
Carbohydrate	469 " "	445·55 " "

∴ Food value is $(64{\cdot}68\times 5)+(8{\cdot}10\times 3)+(445{\cdot}55\times 1)=793$.

Butter: 1,000 grammes contain—

Protein	10 grammes gross, equal to	9·7 grammes digestible.
Fat	810 " "	769·0 " "
Carbohydrate ..	15 " "	14·7 " "

∴ Food value is $(9{\cdot}7\times 5)+(769\times 3)+14{\cdot}7\times 1)=2{,}371$.

Potatoes: 1,000 grammes contain—

Protein	20·0 grammes gross, equal to	16·8 grammes digestible.
Fat	1·6 " "	1·4 " "
Carbohydrate	195·0 " "	185·2 " "

∴ Food value is $(16{\cdot}8\times 5)+(1{\cdot}4\times 3)+(185{\cdot}2\times 1)=273$.

Dried peas: 1,000 grammes contain—

Protein	238 grammes gross, equal to	185·0 grammes digestible.
Fat	18 " "	16·2 " "
Carbohydrate ..	600 " "	570·0 " "

∴ Food value is $(185\times 5)+(16{\cdot}2\times 3)+(570\times 1)=1{,}544$.

Boiled cabbage: 1,000 grammes contain—

Protein	6 grammes gross, equal to	5·00 grammes digestible.
Fat	1 " "	·95 " "
Carbohydrate ..	14 " "	13·30 " "

∴ Food value is $(5\times 5)+(\cdot 95\times 3)+(13{\cdot}3\times 1)=41$.

Raw apples: 1,000 grammes contain—

Protein	4 grammes gross, equal to	3·36 grammes digestible.
Fat	5 " "	4·50 " "
Carbohydrate ..	126 " "	118·70 " "

∴ Food value is $(3{\cdot}36\times 5)+(4{\cdot}5\times 3)+(118{\cdot}7\times 1)=149$.

Calculation of the Constituents in One Ounce of Food: Let the number of grammes per cent. be divided by 3·52, the dividend will represent the grammes per ounce—*e.g.*, one ounce of cooked beef contains 28·5 divided by 3·52 = 8·1 grammes of protein, and 41·25 divided by 3·52 = 11·6 grammes of fat.

TABLE OF FOOD VALUES.

Kind of Food: Edible Portion only.	Percentage Composition.					Heat Value: Calories per Ounce.	Food Value: Comparison of 1,000 Grammes.
	Water.	Protein.	Fat.	Carbo-hydrate.	Ash.		
MEAT.							
Beef—Raw: Average	64·70	18·70	15·70	·50	·90	72	1,333
Roast: Average	48·25	22·25	28·55	—	1·25	160	1,868
Minimum	37·90	15·15	19·85	—	·75	100	1,299
Maximum	60·00	28·50	41·25	—	2·65	210	2,757
Roast ribs: Fat	45·20	19·14	39·04	—	·82	122	2,057
Average	57·00	17·18	24·60	—	·90	87	1,530
Boiled: Average	39·10	26·30	35·00	—	1·00	175	2,268
Broiled steak	44·25	23·45	26·50	—	1·43	100	1,942
Very lean	62·75	27·65	7·56	—	1·75	52	1,557
Corned beef	51·19	26·32	18·65	—	4·10	80	1,810
Veal: Raw	70·90	20·71	8·35	—	1·00	46	1,242
Cooked: Average	51·88	32·20	11·49	—	1·50	68	1,896
Leg	64·88	28·21	5·11	—	1·05	—	1,713
Mutton—Raw: Average	53·10	16·25	30·65	—	1·05	100	1,560
Roast: Average	51·00	26·00	22·60	—	1·19	90	1,805
Boiled leg	57·67	27·60	14·38	—	1·05	67	1,738
Lamb: Raw leg	63·90	19·20	16·50	—	1·10	66	1,501
Raw loin	53·10	18·70	28·30	—	1·00	96	1,413
Roast leg	67·10	19·70	12·70	—	·80	66	1,318
Various parts	47·25	23·80	28·50	—	1·25	100	1,966
Pork: Raw leg	53·90	15·30	29·00	—	·89	95	1,568
Raw loin	52·00	16·60	30·00	—	1·00	99	1,660
Roast leg	54·42	23·98	19·37	—	1·03	84	1,685
Various parts	45·00	32·00	20·00	—	1·76	90	2,122
Horsemeat, cooked: Average	69·81	19·47	9·61	1·82	1·02	57	1,243
Suet: Beef	13·70	4·70	81·80	—	—	221	2,559
Mutton	3·40	1·80	95·40	—	—	251	2,794
Organs: Heart	62·60	16·60	20·00	—	1·00	70	1,370

TABLE OF FOOD VALUES—*Continued.*

Kind of Food: Edible Portion only.	Percentage Composition.					Heat Value: Calories per Ounce.	Food Value: Comparison of 1,000 Grammes.
	Water.	Protein.	Fat.	Carbo-hydrate.	Ash.		
MEAT—*continued.*							
Organs: Kidney of ox	76·15	16·50	4·90	·40	1·20	32	940
Kidney of sheep	78·65	16·60	3·30	·50	1·30	28	924
Liver of ox	71·00	20·60	4·60	1·80	1·50	38	1,150
of sheep	62·50	23·10	8·50	4·50	1·80	56	1,266
of pig	71·60	21·70	4·50	1·50	1·60	40	1,205
Sweetbread	71·00	16·80	12·00	—	1·60	51	1,157
Tongue of ox	71·00	19·00	9·00	—	1·00	46	1,188
of sheep	67·50	14·00	17·50	—	·50	62	1,160
Tripe	73·00	16·80	8·50	1·20	·50	24	830
Hare	69·00	25·50	4·00	—	1·50	40	1,250
Rabbit	71·00	23·00	4·50	—	1·50	38	1,243
SOUP, ETC.							
Beef-tea	93·00	4·30	·50	1·10	1·10	8	234
Bouillon	96·50	2·30	·10	·20	·90	3	116
Chicken broth	94·00	3·80	·10	1·80	1·00	6	200
Consommé	95·50	2·40	·10	·30	1·10	3	120
Meat hash	80·00	6·50	2·00	9·00	2·40	24	560
Stew	84·50	4·60	4·30	5·50	1·10	23	420
Oxtail soup	89·00	4·00	1·50	4·30	1·50	13	278
Pea soup	87·00	4·00	·80	8·50	1·30	15	291
Soup stock (beef)	89·10	5·80	1·50	—	3·60	11	324
Tomato soup	89·00	2·00	1·50	5·50	1·30	12	158
Meat-juice (natural): Average	90·00	5·37	·19	—	1·36	7	269
Soluble meat (*à la Leube*)	67·21	17·51	5·93	—	1·34	34	1,018
Extract of beef[1]	18·35	10·00	—	—	23·65	—	—
Powdered beef	5·00	73·80	12·10	—	2·20	114	3,924
Peptonized beef (powder)	14·35	62·25	8·00	—	5·30	93	3,307

BIRDS.							
Birds, flesh of: Average	74·00	21·00	3·90	—	1·00	65	1,124
Fowl, domestic: Average	64·00	19·00	16·00	—	1·00	65	1,130
Chicken	67·00	22·70	10·00	—	1·00	62	1,395
Capon	56·00	21·80	21·00	—	1·30	91	1,656
Duck	55·75	17·50	25·00	—	1·00	95	1,554
Goose	52·00	16·50	35·10	—	1·20	110	1,800
Guinea-fowl	67·00	25·20	7·00	—	1·30	59	1,422
Partridge	71·60	25·35	1·45	—	1·00	44	1,271
Pheasant	70·15	24·75	3·25	—	1·10	51	1,302
Turkey	55·50	21·10	23·00	—	1·00	85	1,679
Cooked birds :							
Roast capon	59·00	27·00	11·50	—	1·30	60	1,677
Chicken	66·90	22·00	8·10	—	1·70	58	1,298
Boiled fowl	57·60	27·00	12·80	—	1·90	80	1,708
Roast plover with sauce	57·80	22·50	10·10	7·60	2·00	61	1,381
Quail ,, ,,	70·00	21·70	8·12	1·60	1·50	49	1,304
Turkey	52·00	27·80	18·50	—	1·30	82	1,872
BIRDS' EGGS.							
Birds' eggs: Average	72·10	13·60	11·50	—	1·00	47	983
Fowls' eggs: Raw	73·70	13·40	11·50	—	1·00	45	983
Boiled	73·20	13·20	12·00	—	·80	48	972
White	86·30	12·80	·20	—	·70	16	633
Yolk	50·00	14·80	33·70	—	1·20	106	1,883
Guinea-fowl's egg	73·00	13·50	12·00	—	1·00	47	997
Plover's egg	74·50	11·60	11·50	—	1·10	44	878
Duck's egg	71·00	13·30	14·70	—	1·00	54	990
Goose's egg	69·70	13·70	14·30	—	1·00	54	1,072
Turkey's egg	73·60	13·50	11·30	—	·90	45	977
FISH AND SHELLFISH.							
Alewives	74·40	19·40	4·90	—	1·50	36	1,081
Bass	76·70	20·60	1·70	—	1·20	28	1,048
Blackfish	79·40	18·50	1·40	—	1.30	26	937
Bluefish	78·50	19·10	1·20	—	1·20	27	935

1 Also contains extractives—viz., nitrogenous 30 per cent., non-nitrogenous 18 per cent.

TABLE OF FOOD VALUES—*Continued.*

Kind of Food: Edible Portion only.	Percentage Composition. Water.	Protein.	Fat.	Carbo-hydrate.	Ash.	Heat Value: Calories per Ounce.	Food Value: Comparison of 1,000 Grammes.
FISH AND SHELLFISH—*continued.*							
Brill	87·00	11·89	·50	—	·80	11	720
Ciscoe	73·00	18·50	6·80	—	1·70	40	1,108
Clam: Long	85·80	8·60	1·00	2·00	2·60	17	474
Round	86·20	6·50	·50	4·10	2·70	21	370
Cod: Whole fish	82·60	15·70	·40	—	1·50	20	772
Steak	79·70	18·70	·50	—	·40	22	925
Conger-eel	72·00	18·00	8·50	—	1·30	43	1,121
Crab	77·60	16·80	2·20	1·30	2·10	23	882
Crayfish	81·20	16·00	·50	·10	1·40	23	791
Dab	86·10	11·90	·30	—	1·70	11	584
Eel	74·60	18·70	9·10	—	1·00	46	1,164
Flounder	83·80	14·30	·60	—	1·30	12	867
Haddock: Fresh	81·40	17·20	·30	—	1·10	21	922
Smoked	72·40	23·70	·30	—	3·60	28	1,154
Cooked	68·40	22·30	2·30	—	6·70	33	1,146
Hake	82·20	15·30	·70	—	1·00	20	760
Halibut steak	74·80	18·50	5·30	—	1·40	35	850
Herring	71·50	19·50	7·60	—	1·40	41	1,170
Ling	84·00	16·00	·90	—	1·00	22	802
Lobster	79·50	16·20	1·60	·50	2·10	25	835
Mackerel	74·80	18·50	6·50	—	1·10	40	1,086
Mullet	74·90	19·50	4·50	—	1·10	35	1,065
Mussels	78·60	12·60	1·70	5·30	1·70	18	710
Oysters	80·00	10·60	2·60	6·50	1·30	25	655
Pecten (scallop)	80·20	15·00	1·50	2·00	1·30	22	790
Perch	75·70	19·00	4·00	—	1·20	33	1,049
Pike	75·70	19·30	2·50	—	1·10	30	1,007
Plaice	86·00	11·90	·50	—	·90	16	590

Pollack	76·00	21·60	·80	—	1·50	27	1,060
Salmon	64·60	22·00	12·80	—	1·40	59	1,430
Atlantic	63·60	21·60	13·90	—	1·40	64	1,445
Pacific	63·60	17·50	17·80	—	1·10	67	1,370
Sardines	56·30	24·80	12·70	—	5·00	79	1,560
Shad	70·60	18·50	9·50	—	1·30	47	1,170
Roe	71·20	21·00	3·80	2·50	1·50	38	1,252
Shrimps and prawns	70·80	25·40	1·00	·20	2·60	32	1,044
Skate, ray	79·20	18·20	1·40	—	1·20	25	924
Sole	86·10	11·90	·20	—	1·60	16	578
Trout: Brook	77·70	19·30	2·10	—	1·20	28	995
Lake	69·30	18·30	10·60	—	1·20	48	1,190
Salmon	70·80	17·80	10·20	—	1·20	48	1,156
Tunny	72·70	20·30	4·20	—	1·70	53	1,218
Turbot	70·40	14·80	14·40	—	1·30	55	1,126
Whiting	81·00	17·00	·50	—	1·40	22	825
Isinglass, or fish gelatin[1]	9·00	89·00	1·50	—	2·00	110	918
Gelatin from connective tissues[1]	13·50	91·50	·10	—	2·10	106	890
Calf's-foot jelly[1]	77·50	4·50	—	17·40	·70	26	210
MILK PRODUCTS.							
Cow's milk: Average	87·30	3·50	3·70	4·60	·73	20	320
Skimmed	90·30	4·00	·20	4·60	·83	11	245
Condensed milk: Full cream, unsweetened	62·40	10·60	10·80	14·10	2·00	52	973
Full cream, sweetened	20·00	10·50	9·90	57·50	2·10	100	1,368
Skimmed and sweetened	26·40	10·40	·90	60·20	2·10	40	1,232
Dried entire milk powder	5·40	28·50	29·30	31·40	6·20	138	2,547
Dried skimmed milk powder	9·00	40·00	2·00	36·60	5·50	94	2,357
Casein preparations: Average	8·00	80·20	1·50	?	9·30	97	3,923
Cream: Hand-skimmed	74·00	2·50	18·50	4·50	·50	56	210
Commercial "single cream"	—	—	25·00	—	—	66	—
Commercial "double cream"	—	—	45·00	—	—	—	—
Whey	94·00	1·20	·05	4·60	·70	8	110
Buttermilk	90·00	3·20	1·20	5·00	·60	10	238

[1] The proteins of this group are not tissue-formers, and therefore have not the same value as other proteins; but they are protein protectors, and may be considered equal to carbohydrates.

TABLE OF FOOD VALUES—*Continued.*

Kind of Food: Edible Portion only.	Percentage Composition.					Heat Value: Calories per Ounce.	Food Value: Comparison of 1,000 Grammes.
	Water.	Protein.	Fat.	Carbo-hydrate.	Ash.		
MILK PRODUCTS—*continued.*							
Cheese—Full cream: Average	34·20	26·00	33·50	2·50	3·80	122	2,441
From partly skimmed milk	38·20	25·20	29·50	3·50	3·30	112	1,910
From wholly skimmed milk	45·30	32·00	16·50	2·00	4·20	85	2,140
Butter: Best	13·00	1·00	82·50	1·50	2·00	225	2,371
Second quality	16·00	2·00	73·00	4·00	5·00	203	2,235
Margarine	16·00	1·10	76·70	—	6·30	220	2,210
Lard: Refined	—	—	100·00	—	—	263	2,850
Unrefined	4·80	2·20	94·00	—	·10	221	2,775
CEREAL FOODS.							
Wheat	13·50	12·00	1·80	68·70	1·70	116	1,242
Flour: Superfine white	10·50	11·90	1·60	75·40	·50	114	1,283
Entire wheat	10·80	12·20	2·20	73·60	1·00	114	1,300
Graham	8·60	12·60	2·40	74·50	1·70	116	1,330
Barley	12·30	10·00	2·20	68·70	2·50	102	1,157
Pearl (decorticated)	12·70	7·40	1·20	76·70	2·20	104	1,118
Flour	11·90	10·00	2·10	72·50	2·60	103	1,192
Buckwheat	14·50	11·30	2·70	61·50	2·10	104	1,155
Flour	14·00	7·20	·90	77·40	·50	101	1,090
Durra (sorghum)	12·50	9·30	2·00	72·30	1·70	100	1,154
Maize	10·90	10·20	4·80	71·00	1·30	—	1,242
Meal	12·50	7·10	1·30	78·30	·60	108	1,106
Millet	12·00	12·60	4·60	62·20	2·80	97	1,309
Rice	12·40	6·90	·40	79·40	·50	102	1,084
Flaked	9·50	7·90	·40	81·90	·30	105	1,164
Flour	10·80	7·20	·10	80·00	·90	105	1,020
Ground	12·00	5·00	·50	82·00	·50	105	1,030

Rye	13·50	11·00	1·80	69·50	2·20	102	1,199
Flour	14·20	10·90	1·90	69·70	1·40	100	1,202
Oats	12·90	10·50	5·30	58·50	3·10	115	1,163
Rolled	7·70	16·70	7·30	66·20	2·10	116	1,555
Oatmeal: Fine	9·00	16·20	7·50	60·00	1·70	116	1,479
Coarse	8·50	14·50	8·70	65·00	1·80	114	1,438
Arrowroot	2·30	—	—	97·50	·20	114	956
Barley-water	96·00	·70	·10	2·90	·30	5	59
Cornflour (maize starch)	—	—	—	90·00	—	100	882
Macaroni	10·30	13·40	·90	74·30	1·30	100	1,206
Cooked	78·40	3·00	1·50	15·80	1·30	26	558
Oatmeal, boiled	84·50	2·80	·50	11·50	·70	18	244
Water gruel	91·60	1·20	·40	6·30	·50	10	124
Rice, boiled	72·50	2·80	·10	24·50	·20	45	258
Sago	11·40	·40	·10	88·00	·10	100	882
Vermicelli	11·00	10·90	2·00	72·00	4·10	100	1,223
BREAD.							
White: Best	44·10	7·70	·90	46·90	·30	71	793
Second	38·10	8·30	·20	53·00	·40	77	874
Entire wheat	49·10	7·40	1·10	41·70	·50	65	770
Brown (Graham)	47·20	7·70	1·20	42·80	·90	67	780
Gluten bread	38·20	9·30	1·40	49·80	1·30	72	910
Toasted bread	24·00	11·50	1·60	61·20	1·70	90	1,126
Torrefied bread	1·80	10·50	1·20	85·50	1·00	118	1,312
Zwiebach	5·80	9·80	9·90	73·50	1·00	125	1,399
PUDDINGS, ETC.							
Apple pie	42·50	3·10	9·80	43·00	1·80	80	866
Cornflour blancmange	66·00	2·60	3·10	27·00	1·00	36	456
Custard with crust	62·40	4·20	6·30	26·10	1·00	52	604
Maize pudding (Indian meal)	60·00	5·50	5·00	28·00	1·40	51	638
Mince pie	42·00	5·80	12·00	38·00	2·40	82	939
Rice pudding	60·00	4·00	4·70	32·00	·60	52	608

TABLE OF FOOD VALUES—*Continued.*

Kind of Food: Edible Portion only.	Percentage Composition.					Heat Value: Calories per Ounce.	Food Value: Comparison of 1,000 Grammes.
	Water.	Protein.	Fat.	Carbo-hydrate.	Ash.		
PUDDINGS, ETC.—*continued.*							
Sago pudding	70·00	3·90	4·50	37·00	·90	50	650
Suet pudding	46·90	5·60	10·00	36·00	1·50	117	861
Tapioca pudding	64-50	3·30	3·20	28·50	·80	45	505
With apples	70·10	·30	·10	30·00	·20	36	289
Yorkshire pudding	71·30	5·80	7·50	13·40	2·00	35	567
ROOTS AND TUBERS.							
Beetroot	87·50	1·50	·10	9·80	1·10	16	162
Boiled	91·70	1·40	·10	5·13	1·00	11	102
Carrots	84·00	1·20	·30	9·50	1·00	14	150
Boiled	92·50	·50	·20	4·50	·80	8	70
Jerusalem artichokes	79·50	2·50	·20	16·60	1·00	23	278
Boiled	91·60	1·80	·08	4·60	1·00	7	62
Parsnips	76·80	1·60	·60	12·50	1·10	19	195
Boiled	92·10	1·30	·30	6·50	·70	11	126
Potatoes	75·60	2·00	·16	19·50	1·00	24	273
Boiled	75·50	2·50	·10	21·00	1·00	26	312
Mashed, with cream	75·10	2·60	3·00	17·80	1·50	31	364
Fried in fat	2·20	6·80	39·80	46·70	4·50	166	1,807
Radishes	91·80	1·30	·10	5·80	1·00	8	114
Salsify	86·60	1·30	·40	10·50	1·10	14	168
Boiled	87·30	1·10	·10	8·50	·30	13	132
Turnips	87·50	1·30	·20	8·50	1·50	8	142
VEGETABLES.							
Artichokes, green (canned)	92·50	·80	5·00	·60	1·70	16	177
Asparagus	93·50	1·90	·30	2·60	·80	6	114
Cooked and buttered	91·60	2·10	3·30	2·20	·80	30	200

Brussels sprouts	86·60	4·80	·50	6·20	·80	18	219
Boiled	93·70	1·50	·10	3·40	·20	6	98
Cabbage	85·50	2·30	·70	5·10	1·70	9	89
Boiled	97·00	·60	·10	1·40	·20	3	41
Varieties : Cabbage sprouts	88·20	4·70	1·10	4·30	1·70	14	266
Boiled	97·00	1·30	·10	2·40	·80	5	80
Drumhead	89·50	1·50	·08	7·00	1·10	—	70
Boiled	95·50	·50	—	3·20	·80	—	51
Greens or curly kale	87·30	4·50	·60	6·30	1·20	14	245
Boiled	94·00	1·80	·10	3·20	·70	6	113
Savoy	82·00	3·30	·70	6·00	1·50	—	214
Boiled	96·40	·90	·20	2·80	·70	—	73
Turnip cabbage (kohlrabi)	81·30	3·90	1·50	5·60	2·10	15	245
Tops: White	88·00	2·50	—	3·80	1·80	—	141
Swede	86·50	3·20	—	4·30	1·80	—	175
Cauliflower: Raw	91·00	2·00	·50	4·60	·70	—	147
Boiled	97·30	·60	·10	1·40	·50	—	41
Celery, boiled	97·00	·40	·07	1·00	·50	—	26
Cucumber	94·90	·70	·20	3·10	·50	—	64
Boiled	97·40	·20	·20	2·90	·50	—	41
Green peas (shelled)	79·50	6·00	—	13·00	1·10	29	345
Boiled	73·80	6·70	2·50	14·60	1·50	34	588
Kidney beans (snap or string)	89·20	2·30	·30	7·40	·80	12	176
Boiled	93·30	·80	1·10	1·90	·90	6	82
Mushrooms: Common	91·10	3·75	·20	3·50	·50	9	195
Cultivated	91·10	2·57	·10	4·80	·70	—	156
Milky agaric	89·00	1·88	·50	4·50	·80	—	141
Chanterelle	91·00	1·19	·60	5·10	1·20	—	115
Boletus	84·10	3·70	·40	4·60	·70	—	219
Morel	90·00	4·40	·30	1·60	1·00	—	196
Truffles	73·00	6·10	·60	6·00	2·00	—	328
Spinach	90·30	3·10	·50	3·40	1·90	9	175
Vegetable marrow, or squash	94·80	·60	·20	2·60	·50	4	55

TABLE OF FOOD VALUES—*Continued.*

Kind of Food: Edible Portion only.	Percentage Composition.					Heat Value: Calories per Ounce.	Food Value: Comparison of 1,000 Grammes.
	Water.	Protein.	Fat.	Carbo-hydrate.	Ash.		
SALADS.							
Celery	94·5	1·1	·1	9·7	1·0	13	144
Cucumber	94·9	·7	·2	3·1	·5	4	64
Endive	93·0	1·0	·1	3·0	·6	8	73
Lettuce	93·8	1·8	·6	4·8	1·2	9	138
Onions	87·6	1·6	·3	9·5	1·1	13	167
Spring	87·1	1·0	·1	11·0	·6	13	152
Radishes	91·8	1·2	·1	5·6	·7	5	107
Tomatoes	94·2	1·0	·4	3·9	·5	7	90
Watercress	92·8	·7	·4	4·0	1·2	6	79
DRIED LEGUMES.							
Peas	9·5	23·8	1·8	60·3	2·6	104	1,544
Pea flour	11·5	25·0	3·0	58·0	2·5	106	1,564
Haricot beans	12·6	22·5	1·9	59·6	3·5	100	1,654
Butter beans	10·5	20·6	2·0	62·6	4·2	102	1,519
Soy beans	10·8	34·0	16·8	33·7	4·7	116	2,179
Bean flour	11·5	26·2	2·5	57·2	2·3	—	1,624
Lentils	10·5	24·4	1·5	57·3	3·7	101	1,608
Lentil flour	10·0	22·0	1·5	65·2	2·2	—	1,588
NUTS.							
Almonds: Fresh	27·7	16·5	41·0	12·8	2·0	167	878
Dried	4·8	21·0	54·9	17·3	2·5	189	2,645
Brazil nuts	5·4	18·0	66·0	8·0	2·7	204	2,606
Butternuts	4·5	28·0	61·0	3·5	2·9	192	2,956

Chestnuts	4·8	11·6	15·3	65·7	2·6	117	1,537
Cocoanut: Fresh	19·2	5·4	51·0	10·0	1·2	108	—
Dried	3·5	6·3	57·4	31·5	1·3	173	—
Hazel and filbert nuts: Fresh..	48·0	8·0	28·5	11·5	1·5	160	—
Dried	3·7	15·0	66·0	10·0	1·9	205	2,522
Peanuts	9·2	26·0	38·6	24·2	2·0	160	2,071
Pinenuts	5·1	28·0	53·5	8·5	4·6	200	—
Walnuts: Fresh..	44·5	12·0	31·5	9·4	1·8	120	—
Dried	4·9	15·5	62·7	7·5	1·9	190	2,364
FRUIT, ETC.							
Apples: Raw	85·2	·4	·5	12·6	·3	18	149
Cooked and sweetened	66·1	·2	·8	37·2	·7	46	395
Dried	28·1	1·6	2·2	66·1	2·0	84	753
Apple pie, sweetened	42·5	3·1	9·8	42·8	1·8	80	706
Apricots	85·0	1·1	—	13·4	·5	18	176
Canned	81·4	·9	—	17·3	·4	21	208
Bananas	75·7	1·3	·5	21·7	·7	29	276
Bilberries	77·5	·8	—	5·8	·8	12	64
Blackberries	86·3	1·3	1·0	8·4	·5	17	120
Cherries	82·0	·9	·8	14·3	·6	23	197
Cranberries	88·9	·5	·6	4·0	·2	14	76
Currants: Black	79·0	·5	·3	13·1	·7	23	42
Red	85·2	·5	·3	6·5	·5	17	93
Dates, dried	20·0	3·5	2·3	69·0	1·3	101	885
Figs: Green	79·1	1·5	—	18·8	·5	24	255
Dried	22·7	4·3	·7	62·5	1·3	80	805
Stewed	56·5	1·2	·3	40·9	1·1	49	458
Fruit jelly	38·2	·4	—	60·5	·5	71	604
Gooseberries	85·7	·4	—	8·5	·3	16	99
Grapes: Fresh	80·5	·9	·8	14·7	·5	28	201
Dried—Raisins	18·6	3·0	2·8	70·5	2·7	100	876
Currants	22·6	1·8	2·4	69·5	3·3	94	684

TABLE OF FOOD VALUES—*Continued.*

Kind of Food: Edible Portion only.	Percentage Composition.					Heat Value: Calories per Ounce.	Food Value: Comparison of 1,000 Grammes.
	Water.	Protein.	Fat.	Carbo-hydrate.	Ash.		
FRUIT, ETC.—*continued.*							
Jam or preserves: Average	30·5	1·5	—	60·0	·5	70	744
Melon	89·5	·6	·3	7·2	·6	11	103
Mulberries	84·7	·4	—	11·4	·5	18	130
Oranges	82·8	·9	·2	10·6	·7	15	146
Marmalade	14·7	·6	·1	84·5	·3	98	848
Peaches	88·8	·5	·2	9·2	·6	12	117
Canned	88·1	·7	·1	10·8	·3	14	128
Pears	80·9	·9	·5	15·7	·4	18	203
Canned	81·1	·3	·3	18·0	·3	22	195
Dried	16·5	2·8	5·4	72·9	2·4	100	971
Persimmon	66·1	1·0	·7	29·0	·9	39	342
Pineapples	89·3	·4	·3	10·0	·9	13	112
Plums	74·5	·9	·2	19·1	·5	24	200
Prunes: Dried	22·3	2·1	·2	73·3	2·3	86	724
Stewed	76·6	·5	·1	22·3	·5	27	243
Raspberries	86·2	·5	—	5·6	·5	16	76
Rhubarb stalks (pie plant)	90·4	·6	·7	2·5	·7	6	68
Strawberries	94·0	1·0	·6	8·8	·6	12	144
Tomatoes	94·2	1·0	·4	3·9	·5	7	90
Water-melon	92·1	·8	·1	6·4	·2	9	96
Whortleberries	82·4	·7	3·0	10·2	·4	24	200

CHAPTER I

THE DIGESTION AND ABSORPTION OF FOOD

THE elements which constitute the material of our body are derived from food. But our food undergoes various changes in its character and constitution before it is transformed into flesh and blood, and it is not *directly* converted into flesh and blood; it is assimilated by the tissues already existing. Assimilation is the function possessed by living cells of taking up extraneous substances and making them a part and parcel of their own material. The dead food has not life conferred on it immediately, but it becomes living by assimilation to living substance. Assimilation is necessary for the growth and reproduction of individual cells; assimilation provides for the development and growth of the whole community of cells or animal body; and the same process makes good the losses of the community caused by the incessant activity of the functional divisions or organs, the wear and tear of the communal machinery by muscular work and exercise, and the production of heat and energy.

The changes which food undergoes in the alimentary canal are physical and chemical. While being finely divided and reduced to a pulp in the mouth, the food is mixed with saliva and brought under the influence of its enzymes. The action of *ptyalin* is shown by the following equation:

$$\underset{\text{Starch}}{10(C_6H_{10}O_5)n} + \underset{\text{Water}}{4(H_2O)n} = \underset{\text{Maltose}}{4(C_{12}H_{22}O_{11})n} + \underset{\text{Achroo-dextrin}}{(C_6H_{10}O_5)n} + \underset{\text{Erythro-dextrin}}{(C_6H_{10}O_5)n}.$$

Starch is first converted to amidulin, or soluble starch, then into erythro-dextrin, and the latter into various types of achroo-dextrin, and finally into sugar. Most of the sugar arising from salivary digestion is maltose; but the secretion contains another enzyme called *glucase*, which transforms some of the maltose into dextrose. The secretion of saliva is an important aid to deglutition; it is stimulated by careful mastication and provocatives, such as pepper, mustard, or horseradish. But the food stays in the mouth such a short time that the action of saliva is not completed therein; the secretion is swallowed with the food, and its enzyme continues to act on the starch until it is checked by the presence of gastric juice.

The gastric juice contains several enzymes—namely, pepsin, the

proteolytic enzyme; rennin, the milk-curdling ferment; and lipase, the fat-splitting ferment. The uses of the gastric juice are—(*a*) digestive, (*b*) activating, and (*c*) disinfecting. The secretion of this fluid continues for a period which varies with the nature of the gastric contents. There are two chief phases or periods of gastric secretion: (*a*) The psychic or appetite juice; and (*b*) the chemical juice.

(*a*) *The Psychic or Appetite Juice.*—This is called forth by the desire, thought, taste, smell, and enjoyment, of food, especially in genial company and pleasant surroundings; but it is inhibited by pain, discomfort, worry, mental distress, and fatigue of mind or body.

(*b*) *The Chemical Juice.*—In the second phase or period of gastric digestion, the exciting agent is the presence of food in the stomach. It was shown by Bayliss and Starling that a correlation of the functions of the different organs of the body is brought about by **hormones,** or chemical messengers. The hormone of gastric digestion is produced from proteins in the early stage of digestion, and this shows the importance of the psychic or appetite juice. A similar effect is produced in men and animals by meat extracts and infusions, which are well-known provocatives of gastric secretion.

The changes which food undergoes in the stomach are as follows: The food is disintegrated; meat is broken up, gelatin dissolved; the muscular fibres fall apart, and are split into discs and sarcous elements; the framework of fatty tissues undergoes similar dissolution, and fat is set free by dissolution of cellular membranes. Milk is curdled; the caseinogen is transformed to casein, and the latter broken down by pepsin. Bread and other starchy foods are disintegrated, some of the starch being transformed to sugar by ptyalin. The other vegetable foods are but little digested in this viscus. The whole is broken into irregular fragments by the disintegrating power of the stomach, and gradually converted into **chyme**—the creamy emulsion which passes through the pylorus into the intestines. The passage from the stomach into the duodenum is aided by the motor activity of this organ.

The passage of food through the alimentary canal has been studied by the X rays. For this observation the food is mixed with bismuth, which throws a shadow on the screen. Deglutition is reflex. When this action is not in process, the walls of the œsophagus are in contact. A mouthful of fluid takes five to eight seconds to pass from the pharynx into the stomach, about half the time being occupied in going through the cardiac sphincter. But the passage of solid food occupies a longer time, unless it is immediately followed by a mouthful of fluid. The stomach is divided into the cardiac portion, or fundus, the pyloric antrum, and the pylorus. During digestion the fundus is divided from the pyloric antrum by the transverse band of Home. This division is rarely observed in the cadaver, except in frozen specimens of the digesting stomach; but it is seen by means of the X rays. The fundus is the storehouse;

in it the bulk of the food forms a mass round which the muscular walls contract. The reaction in the centre of this mass remains alkaline for at least two hours, during which period salivary digestion is going on; while the outer portions are gradually permeated by the acid gastric juice, and the softened parts are squeezed off and driven into the pyloric antrum. The pyloric portion is the most active part of the stomach; here the reaction is entirely acid, and waves of peristaltic movement are visible. These have been described by Holzknecht, Hertz, and Cannon. They occur at regular intervals of fifteen to twenty seconds, and serve a double purpose. When the pylorus relaxes, food which is fine enough to pass is driven through by peristalsis; if the food is not fine enough, the pyloric sphincter spasmodically closes, and it is returned by a central reflux; and thus the food is circulated, thoroughly churned, and mixed with the gastric juice. The pylorus is stimulated to relax by the presence of acid liquid food, which is squirted periodically through the opening by the wave of contraction; and an alkaline reaction in the duodenum favours the relaxation. The pylorus is stimulated to contract by the projection of undigested food against it, and by the presence of acid food in the duodenum. The effect of acid and alkaline fluids on the pylorus was experimentally proved by Pawlow. The injection of a solution of 0·10 per cent. of hydrochloric acid through a fistula into the duodenum caused the pylorus to contract, but the injection of alkaline solutions and plain water had no such effect.

The nature of the food influences the rate of its passage through the pylorus. Cannon showed by means of the X rays that when the meal consisted of lean meat, suet, and rice, properly cooked and prepared in such a manner that the constituents were thoroughly mixed together, the carbohydrates (rice) began to leave the stomach in fifteen minutes, but the protein (lean meat) and fat did not begin to leave under half an hour, and were much longer in passing through. He found that in a normal stomach a meal of rice or potatoes got out of the stomach rapidly, no trace being left in three hours; a meal of protein and fat (fat meat) was much slower, some being present six hours after the meal. Indigestible substances are rejected by the sphincter and returned to the digesting cavity over and over again; but in process of time the sphincter relaxes, and the peristaltic contractions increase until the force is sufficient to drive through the opening hard substances like peas, plum-stones, and coins. Beer leaves the stomach more slowly than water, and salt solutions are retained until they become isotonic with the gastric juice. Thus the stomach protects the intestines from the injurious effects of many substances by retaining them until their condition is changed.

The action of gastric juice on foods is as follows: Most **proteins** yield proteoses and peptones, but certain substances called "parapeptone" and "anti-albuminate" occur; while the nucleo-proteins and phospho-proteins leave an insoluble residue called "dyspep-

tone." The *proteoses* are proto-proteose and hetero-proteose. Proto-proteose from fibrin yields considerable tyrosin and indol, little leucin, and no glycocoll; it contains 25 per cent. of basic nitrogen. Hetero-proteose from muscle-syntonin yields very little tyrosin and indol, but an abundance of leucin and glycocoll, is richer in arginin, but poorer in histidin, than proto-proteose, and contains 39 per cent. of basic nitrogen. The *peptones* are also mixtures of the same and other amino-acids. According to Siegfried and Krüger, pepsin-fibrin peptone = $C_{21}H_{34}N_6O_9$, and pepsin-gluten peptone = $C_{23}H_{39}N_7O_{10}$. They belong to the amphi-peptones of Kühne's series, and are converted by trypsin into anti-peptones or polypeptides.

The action of pepsin on other bodies varies according to their nature. **Collagen** is converted first into gelatin, and then into gelatin-proteose and gelatin-peptone, which yield amino-acids. **Mucin,** the cement substance of cells, yields substances similar to peptones. **Elastin** is dissolved very slowly and yields very little peptone, but proteoses are produced which yield amino-acids on tryptic digestion. **Keratin** is insoluble. The action on animal cell-membranes varies: the nearer they are to elastin, the greater is the proportion dissolved; the nearer they are to keratin, the less is dissolved. Plant cell-membranes (*cellulose*) are not acted on by gastric juice. Starch and sugar are not acted on. The connective tissue and cell-membranes of fatty tissues are digested by pepsin; fats—*e.g.*, suet, oil, and butter—are not acted on; but emulsified fats, like egg-yolk, milk, and cream, are acted on by lipase. Milk is coagulated by rennin, and the casein peptonized by gastric juice.

Digestion in the intestines is due to the combined action of the bile, pancreatic juice, and succus entericus. It is unnecessary to give an account of these secretions, and the reader is referred to works of physiology. The material which enters the duodenum from the stomach is known as "chyme." It consists of—(*a*) The products of digestion up to the pylorus—viz., maltose, dextrose, levulose, proteose, peptone, and gelatin-peptone; (*b*) partly digested matters, such as starch, disintegrated meat, some forms of albumin, connective and elastic tissues, etc.; and (*c*) substances unchanged by saliva or gastric juice—fat, cellulose, and other vegetable matters.

The acid chyme provokes a flow of bile and pancreatic juice. It acts upon the *prosecretin* in the duodenal mucous membrane in such a manner that *secretin*, a hormone, is formed and carried by the blood to the cells of the pancreas, which it stimulates. The pancreatic secretion attains its maximum pressure about three hours after a meal; but, according to Pawlow, this varies according to the food, the maximum pressure being from three to four hours after milk, two hours after bread, and sooner than that after meat. The enzymes of the pancreatic fluid are trypsin, amylopsin, lipase, and pancreatic rennin. Amylase or amylopsin is a diastatic ferment which acts on carbohydrates, the products being 50 per cent. of dextrin, about 50 per cent. of maltose and iso-maltose, and a very

little dextrose. Another enzyme called *lactase* converts lactose into galactose and dextrose, and is an important constituent of this secretion in suckling animals.

Pancreatic juice alone has very little influence on proteins, but when mixed with succus entericus its influence is great. It is believed that this is due to the effect of *entero-kinase*, which converts trypsinogen into trypsin. Trypsin differs from pepsin by acting in an alkaline medium. It successively converts the proteins into alkali-albumin, albumoses, peptones, polypeptides, and amino-acids. It acts more powerfully and rapidly than pepsin; it corrodes protein away, whereas pepsin swells it up; it acts on insoluble proteins such as elastin; it carries the action farther than pepsin, the end-products being amino-acids. Fibrin affords a good example of its effects; it is converted to proteose (albumose) and peptones; the anti-peptone is believed to be absorbed as such, but hemi-peptone is reduced to amino-acids. Trypsin fibrin-peptone = $C_{11}H_{19}N_3O_5$; it is split by hydrolysis into arginin, lysin, glutaminic and aspartic acids. Nucleo-proteins are split into protein and nucleic acid; the protein is digested, the nucleic acid reduced to purin bases and phosphoric acid. The cells of muscle, liver, and other organs, are dissolved and peptonized; but many nuclei resist the action of trypsin. Chondrin and gelatin are converted to gelatin-peptone. Elastin and cell-membranes in general are dissolved. Mucin is dissolved and reduced to amino-acids. Pancreatic rennin converts caseinogen into casein, which is digested by trypsin. Fats are split by lipase or steapsin into glycerin and fatty acids; the latter are saponified by alkaline salts, and the soaps are in turn utilized in the emulsification and absorption of other fats. The greater part of the fat in food is digested by pancreatic lipase, which is activated by the bile.

The bile or secretion of the liver is constantly being manufactured; but the pressure of its flow through the ductus choledochus varies, being lowest during abstinence from food, and highest two or three hours after a meal of carbohydrates or three or four hours after a meal of protein. Less secretion follows the ingestion of carbohydrates than after protein; fatty foods were formerly supposed to check the secretion, but Barbéra and Rosenberg have proved by experiments that fats cause an increased flow of bile, and olive-oil is a powerful cholagogue. Bile precipitates the proteins of the chyme, and the acidity of gastric juice is neutralized by its salts. Bile dissolves fatty acids, and especially oleic acid, about 50 per cent. of the food fats being dissolved by it; it also activates the lipase or steapsin of pancreatic juice, and assists in the absorption of fat by lessening the surface tension of the molecules. The bile salts not only neutralize the gastric juice and precipitate proteins: they dissolve cholesterin, activate steapsin, moisten the intestinal mucous membrane, and render it permeable by fatty substances.

The **succus entericus** is the secretion of the glands of Lieberkühn. It contains quite a number of enzymes, including four which act on carbohydrates—viz., amylase, found chiefly in the duodenum,

converts starch into maltose; maltase, which converts maltose into dextrose; lactase, which occurs chiefly in the jejunum, converts lactose into galactose and dextrose; and invertase, which splits cane-sugar into dextrose and levulose. The proteolytic enzyme is erepsin; it has no action on native proteins, except casein, but it breaks down proteoses and peptones into amino-acids. The kinase converts trypsinogen into trypsin. The lipase of succus entericus dissolves emulsified fat, and it is estimated that about 50 per cent. of the food fat is absorbed by virtue of this effect.

The intestinal movements, like those of the stomach, have recently been studied by the aid of X rays. There are three kinds: (*a*) A pendulum-like motion, consisting of a gentle swaying, rhythmical movement occurring in all parts of the intestines. These movements do not affect the whole gut at one time, but usually successive segments of the gut, and are most obvious in those parts which are distended with food at a period of three or four hours after the meal. Moreover, they are most energetic in the upper, and least so in the lower, parts of the gut, and naturally proceed from above downwards with the course of the food. The movement consists of lengthening and narrowing, followed by shortening and widening, of the canal; the contraction involves both the longitudinal and circular muscular coats, and in the course of its progress divides the bowel into many segments. This movement breaks up the food, sways it backwards and forwards, diffuses the digestive fluids through it, and drives chyle into the lacteals. It is calculated that the mass in each segment of gut is divided, subdivided, and squeezed, about one thousand times, as the contractions occur at the rate of twelve per minute. (*b*) The second kind of movement consists of peristalsis, or wave-like propulsive movement, a localized dilatation followed by contraction of the canal, progressing from above downwards at the rate of one or two inches per second, and is from two to three hours travelling the entire length of the intestine. (*c*) Under pathological conditions a third movement is observed, consisting of a swift vermicular movement, starting at the pylorus, and travelling the entire length of the gut in about a minute. It is produced by toxins, gases, and various irritants.

Digestion is practically completed in the small intestine, for no digestive ferments are secreted in the colon, and the change in the chemical reaction hinders the action of enzymes already mixed in the foods. The colon is divided into three parts: A proximal portion, consisting of the cæcum, ascending colon, and half the transverse colon; a mesial part, formed by the other half of the transverse colon and part of the descending colon; a distal portion, formed by the remainder of the descending colon and the rectum. The contents of the proximal part are fluid, and are subjected to feeble antiperistaltic movements which last from two to three minutes, alternating with long periods of rest (twenty to thirty minutes). Food accumulates in this portion until it extends to the mesial segment; it is gradually concentrated by the absorption of water. When the

antiperistaltic movement has gone on some time, the cæcum begins to contract periodically, and propels the substance along so that a portion is driven into the mesial portion, where the true peristalsis begins and carries it into the distal segment; here it remains until an evacuation occurs. It has been shown by the X rays that a meal reaches the cæcum in four or five hours, the hepatic flexure in six or seven hours, the splenic flexure in nine hours, and the rectum in about eighteen hours.

The fæces consist of the residue of the food, digestive secretions, etc. The contents of the alimentary canal become altered in character as they descend its course. When it leaves the stomach, chyme is of a yellowish colour and creamy consistence; in the duodenum the addition of bile changes its colour to greenish-grey; the mass attains a greater density as it descends, more and more nutriment being absorbed from it; and even in the colon it becomes more solid, its colour brownish, and its odour characteristic. The residue of various foods in persons whose digestion is normal has been determined by actual experiment to be as follows: Proteins from meat 2·5, eggs 3, milk 11, bread 15 to 25, and vegetables 25 to 48, per cent.; carbohydrates from milk nil, bread 2 to 3, vegetables 5 to 10, per cent.; fat from 1 to 5 per cent., according to its origin. The amount of fæces from an average mixed diet represents one-seventh to one-eighth of the food consumed. It contains the following: (*a*) *Indigestible residues of food :* Vegetable fibres, cellulose, chlorophyll, uncooked starch, gum, resin, mucin, nuclei of cells, connective-tissue fibres, elastic fibres, keratin, chitin, and insoluble salts. (*b*) *Products of the decomposition of food :* Amino-acids, fatty acids, insoluble soaps of calcium and magnesium, etc. (*c*) *Bile residues :* Stercobilin, choletelin, cholesterin, lecithin. (*d*) Bacteria, débris of intestinal matters, and other undigested substances.

The Absorption of Food.—The products of digestion are brought into close relation with the mucous membrane by the muscular movements of the viscera. The stomach absorbs very little, and this consists of peptones, alcohol, and substances dissolved in dilute alcohol. Absorption occurs in the entire length of the gut, but attains a maximum in the ileum. How the substances of our food get out of the lumen of the gut into the blood and become a part of the living body is a matter of extreme interest. Several physical and physiological processes are involved in absorption. When two liquids of different densities are put together, they mingle with each other until the whole liquid is of the same density; this process is called *diffusion*. In like manner, if two liquids of different density are separated by an animal membrane, they mingle together by passing through that membrane until the fluid on each side is of the same density. This process is called *osmosis ;* and the pressure at which the equilibrium is established is called the *osmotic pressure*. The osmotic pressure depends on whether the substance is an electrolyte or non-electrolyte. The osmotic pressure of non-electrolytes in solution is exactly proportional to the number

of contained molecules; but in the case of electrolytes the osmotic pressure is in proportion to the molecules *plus* the ions in the solution. Sugar is a non-electrolyte, and a 1 per cent. solution exerts exactly half the pressure of a 2 per cent. solution. Chloride of sodium is an electrolyte, and a 1 per cent. solution exerts more than half the pressure of a 2 per cent. solution, because the dissociation is greater and there are relatively more ions in the weaker than in the stronger solution. Osmosis is one mode of absorption by cells; it occurs in all animal and vegetable structures, and is an important element in biological processes.

But absorption is not simply an osmotic process. This physical function is subject to modifications brought about by the living cells. The cells consist more or less of living protoplasm, by which diffusion is modified both as to the quantity and quality of the substances which pass in and out; and this is a vital phenomenon. One special phenomenon observed in living cells is the condition of turgescence; it is very important in connection with absorption. Three conditions are essential for its occurrence. One is an elastic cell-wall, which allows of variations in size of the cell; another is the presence in the cell of substances which attract water; and the third is the living protoplasm which controls the phenomenon. The turgidity itself is relieved by another vital phenomenon—the exhalation of water, carbon dioxide, and waste products of the cell. When a piece of gut is excised, and placed in defibrinated blood of the same animal, it will take up fluid into its mucous membrane, and the water and salts absorbed in this way have a tendency to move onward. Moreover, the epithelium has a direct selective affinity, even in the case of salts and water. The absorption of foodstuffs, therefore, is not merely a matter of diffusion and osmosis, but is an effect of vital activity.

It was formerly believed that the main stream of nutriment passed out of the intestines through the lacteals and thoracic duct into the circulation. But it is known now that only fats take that course, and that the dissolved proteins, carbohydrates, some of the fats, and salts, find their way into the circulation through the portal system and the liver. The proteins lose their colloidal character, are no longer coagulable, but are diffusible. It was formerly considered that **proteins** are absorbed almost entirely as proteoses and peptones, together with a small amount of unaltered serum-albumin, egg-albumin, and alkali-albumin. But neither proteose nor peptone can be found in the blood even when the diet is rich in protein; and if peptone be injected into the blood, it is rapidly excreted or broken down by ferments, and entirely disappears from the blood in ten to fifteen minutes. Neither is peptone found in the portal blood. It is therefore clear that the larger portion of protein does not enter the blood as proteose or peptone. The only remaining supposition is that the products of protein digestion are transformed into protein again before they reach the blood. This transformation is due to some vital process, as was proved by Hoff-

meister.[1] Pohl also showed that the number of leucocytes in the blood increases rapidly during the digestion of protein, and that they are derived from the proliferation of lymph cells in the adenoid tissue of the alimentary canal; and their function is the assimilation of the products of protein digestion. But Heidenhain[2] considers this explanation insufficient; he believes the digested proteins are taken up by the epithelial cells of the mucous membrane, and that in these cells the products of digestion are reconverted into proteins, and then surrendered to the blood-plasma in the capillaries immediately beneath the epithelium, and pass into the portal blood-stream. The discovery of erepsin in the succus entericus, and a study of its effects, has led to the view, now almost generally accepted, that the digestion of proteins is carried farther than the stage of proteoses and peptones—in fact, that this enzyme hydrolyzes them into amino-acids, in which form they are taken up by the cells of the intestinal mucous membrane. The blood contains a constant proportion of serum-albumin and serum-globulin, which are constructed out of the amino-acids resulting from the digestion of protein-foods. The reconstruction of proteins takes place chiefly in the cells. Abderhalden and others assert that the cells of the intestinal mucosa take an active part in this reconstruction, and possibly in the supply of proteins to the blood. But it is probable that the proteins are not all reconstructed in the intestinal cells. Leathes found a definite increase of non-protein nitrogenous bodies in blood flowing in the vessels from the intestine. Von Bergmann found amino-acids in such blood. And on similar evidence Fuchs formed the opinion that amino-acids from the food are carried to all the tissues; that the cells of the muscles and glands pick out from the blood the " building-stones " necessary for the construction of their special proteins. There is also evidence of a local hydrolysis of serum-proteins to amino-acids by the cellular enzymes of the tissues, and that out of these amino-acids the tissue cells construct proteins to their own pattern.

All the amino-acids are not used for tissue-building. Those which are not directly used for constructive purposes are broken down; the nitrogenous moiety is split off and converted to urea, and the carbon moiety is used for the production of energy.

Fat is absorbed in the form of an emulsion and as a solution of soap. It was formerly thought that the greater part of the fat was taken up as an emulsion by the epithelial cells, and passed into the lymph stream, because an abundance of fat occurs in the thoracic duct after a meal. But the fat absorbed by the lacteals is not the whole of the fat from the food. When the amount of fat passing through the thoracic duct is compared with that in the food, there is a deficiency of nearly 50 per cent. It is clear, therefore, that at least 40 per cent. of the absorbed fat gets directly into the blood, being taken up as absorbable and soluble soaps, which are some-

[1] Bunge's " Physiological and Pathological Chemistry."
[2] Pflüger's *Archiv*, 1888, xli., *sup.*, 72-74.

where resynthetized into fat. It is not quite clear where this transformation occurs, but it is believed that it occurs directly in the cells of the intestinal epithelium. It was shown by Moore that after the ingestion of fat the mucous membrane contained 15 to 35 per cent. of its fat in the form of fatty acid, while the lymphatics of the mesentery contain only 5 per cent. of their fat in this form. It is clear, therefore, that 95 per cent. of fat in the chyle had been regenerated before leaving the mucous membrane. According to Pflüger, no unsplit fat is absorbed; it is all split into fatty acid and glycerine; and other authorities agree with him that the greater portion of fat is taken up as fatty acid or soap, and synthetized into neutral fat. What becomes of it ? After a meal containing fat, the blood contains a considerable number of fat globules, but they soon disappear. These fat globules are so minute that they traverse the finest capillaries, and, passing through the capillary walls, are taken up by the cells in the connective tissues. The leucocytes in the blood also contain fat globules, which they have carried from the intestinal mucosa or taken up from the blood-plasma. Fat is not decomposed in the bloodvessels, for " oxidation never takes place in the blood," but it is carried by the blood-stream to the tissues all over the body; it is oxidized in the tissues to produce heat and energy; and what is not immediately used for this purpose is stored in the cells for future use.

Carbohydrates are chiefly absorbed as monosaccharides, such as dextrose, levulose, and galactose. The monosaccharides of the food are absorbed unchanged. The disaccharides are all inverted to monosaccharides—*e.g.*, saccharose to dextrose and levulose, maltose to dextrose, lactose to dextrose and galactose. Polysaccharides are converted by enzymes to maltose and dextrose, and the former again to dextrose. The absorption of uninverted carbohydrates is not improbable, for Otto and Von Mering separated a dextrin-like substance from the portal blood after a diet of carbohydrates. A portion of the ingested carbohydrates is destroyed in the alimentary canal by bacteria, whose enzymes transform them into various acids and gases. Practically all the carbohydrates digested are absorbed in the form of sugar. The absorption takes place more rapidly in the upper than the lower bowel; and the rate varies with the kind of sugar. · Monosaccharides are completely absorbed and much sooner than disaccharides. The rate of absorption of the latter varies with the time required for inversion; cane-sugar is absorbed more rapidly than malt-sugar, and milk-sugar more slowly than either. The pentoses are absorbed much more slowly than hexoses; xylose, one of the chief forms, has to be split by hydrolysis from xylan (a pentosan of vegetable tissues) before it is absorbed. The polysaccharides—*e.g.*, starch—are not so completely or rapidly absorbed as ready-formed sugars, because of the longer time required for transformation into monosaccharides, the greater coarseness of the food, the presence of cellulose, etc.

The Absorption of Sugar.—The sugars pass into the blood through the portal circulation, and not through the lymphatic vessels. The reason why they do not diffuse as freely into the lymphatic vessels as into the bloodvessels, according to Heidenhain,[1] is due to the arrangement of the capillaries, close under the epithelium, which ordinarily take up water and all substances in solution—*e.g.*, sugar, —in consequence of which they enter the portal vessels before the lymphatics. Where does the sugar go to after it gets into the blood? The proportion of sugar in the general circulation is no greater after a meal than before it. An adult man has 5 litres of blood, containing 0·5 to 1·5 grammes, or possibly 2 grammes, of sugar per litre; so that at the most the blood never contains more than 10 grammes of sugar. It is necessary, therefore, that there should be some means of storing it, for it cannot all be immediately used in the production of energy. Is it stored as glycogen? Glycogen gradually disappears from the system during work and fasting, and rapidly increases after food, and it is assumed that carbohydrate is chiefly stored in this form. Bunge believes, however, that a considerable amount of carbohydrate is stored as fat. "The total amount of glycogen in the liver of man never exceeds 150 grammes, and there is a similar store in the whole mass of muscles. This store is by no means all used up when a fresh supply of carbohydrate is consumed, and it only disappears from the blood after weeks of starvation. . . . It is evident, therefore, that only a small proportion of the carbohydrate is laid down as glycogen, and we must assume the greater part of it is converted into fat."[2] Sugar is an important source of energy for the muscles, and provision is made for a sufficiency of it to be always present in the blood circulating through them, and the storehouse from which it is derived is the liver. When the liver and muscles contain enough glycogen to keep the blood supplied with it, the excess of sugar is converted into fat, and is reconverted into sugar when there is a demand for it.

The amount of glycogen in the body depends on the amount and kind of food, and the state of rest or activity. It arises from the food, and, briefly put, carbohydrates give rise to most, proteins to some, and fats to no glycogen. Carbohydrates do not equally increase the glycogen: the hexoses cause the greatest increase; dextrose causes a greater increase than cane-sugar; and lactose is less effective than dextrose, levulose, cane-sugar, or maltose.[3] Pentoses—xylose, arabinose, and rhamnose—also increase the glycogen. Polysaccharides increase the glycogen in proportion to the sugar produced from them. Glycogen is also increased by the ingestion of alcohol, glycerin, erythrite, sorbite, mannite, dulcite, inosite, quercite, etc.

Fat of any kind has very little influence in causing an increase of

1 Pflüger's *Archiv*, 43.
2 Bunge's "Physiological and Pathological Chemistry," pp. 188, 189.
3 Voit, *Zeit. für Biol.*, 28.

glycogen in the body, although glycerin increases it. This is the general opinion; but Bouchard and Desgrez[1] state that the amount of glycogen in the muscles is certainly increased by the consumption of fat.

Proteins increase the amount of glycogen in the liver. Kulz, Naunyn, von Mering, and others, observed an increase of glycogen after feeding animals with boiled beef, egg-albumin, serum-albumin, fibrin, casein, and gelatin. Casein and gelatin contain no gluco-protein, and Schöndorff, Blumenthal, and Wohlgemeith, found no increase of glycogen after feeding with them. Pflüger considers that only gluco-proteins cause an increase of glycogen. Most authorities believe that all proteins have this power, but they do not possess it in an equal degree. Various amino-acids, ammonium salts, and inorganic substances, increase the glycogen.

There are several theories as to the cause of this accumulation of glycogen after the ingestion of substances. (1) *The anhydride theory* is that glycogen is an anhydride produced in the liver cells by separating water from sugar and causing its condensation (*polymerization*). (2) *The protein-sparing theory:* according to this, carbohydrates are not the real source of glycogen; it arises from protein which is split into two parts, a nitrogenous part and a non-nitrogenous part, which is glycogen. (3) *The theory of true glycogen-formers:* that is, the carbohydrates are the true formers of glycogen; the amount of glycogen ordinarily produced could not be formed from protein. Cremer[2] says the true glycogen-formers are dextrose, levulose, galactose, and possibly mannose; other carbohydrates only cause the formation of glycogen when they are converted into these monosaccharides.

There are two principal views concerning the after-history of glycogen: (*a*) Pavy's view that it is utilized for the formation of energy and heat without transformation into sugar; and (*b*) Bernard's view that it is transformed into sugar in the liver. Bernard formed his opinion from the belief that the liver always contains some sugar, and that there is more sugar in the blood leaving the liver than in the general circulation. Pavy denied this, and was supported by Schiff and Ritter. Seegen, Kaufmann, Tangl, Minkowski, and others, *after excluding the liver from the circulation*, found that the amount of sugar in the blood sunk to one-third or one-half the original amount, or disappeared entirely, in a few hours; which proved that the sugar was formed in the liver, and, as they believed, by its vital activity.

The excess of carbohydrate in the body does not remain in the form of glycogen; it is probably converted into fat. There is no conclusive proof that fat is formed in the liver, but Bunge is of opinion that some sugar is transformed into fat in the liver. That fat accumulates in the body on a purely carbohydrate diet is proved beyond a doubt; and the formation of fat from sugar is considered

1 Hammarsten's "Physiol. Chem.," p. 350. 2 *Zeit. für Biologie*, xlii.

proved by experimental evidence. The stages in the transformation are not clear, but Magnus-Levy considers the carbohydrate is first reduced to aldehyde and then to fatty acid. Thus:

$$\underset{\text{Sugar}}{9C_6H_{12}O_6} = \underset{\text{Aldehyde}}{18C_2H_4O} + 18H_2 + 18CO_2;$$

$$\text{and } \underset{\text{Aldehyde}}{18C_2H_4O} + 14H_2 = 14H_2O + \underset{\text{Stearic acid}}{2C_{18}H_{36}O_2}.$$

Practical evidence of this transformation is found in the fact that cows give more fat in their milk than is contained in the grass they consume; and Gilbert and Lawes found that a pig accumulated in its body 472 parts of fat for every 100 parts of fat in the food. When the fat of the body is drawn on for supplying heat and energy, it is probably converted—at least, a part of it—into sugar before it is oxidized.

CHAPTER II

THE HEAT VALUE AND DIGESTIBILITY OF FOODS

One of the chief functions of the food is to supply the body with heat and energy. The amount of food required as fuel is ascertained by a study of the income and expenditure of the body on a particular diet. As a general rule, people like to choose their own food, and eat as much as they feel disposed. Other people, with some special object in view, consume a diet in which protein, fat, or carbohydrate, predominates. The amount of food required to supply the body with a definite quantity of heat or energy, however, cannot be determined by haphazard dietaries, such as the customary foods of certain classes of people. These dietaries are empirical, and may be valuable as a guide to the amount and kind of food usually consumed by people under various circumstances; but they are unreliable. The scientific proof that a given dietary is sufficient for the needs of man under particular circumstances has to be determined by experiments in which the balance of nitrogen and carbon is determined. It has likewise been shown that the amount of nitrogenous substance required depends largely upon the supply of fats and carbohydrates. A diet rich in nitrogen, beyond a certain definite amount of digestible protein, has no greater value than an isodynamic quantity of fat or carbohydrate. As sources of energy, protein, fat, and carbohydrate, can replace each other in the ratio of 1 : 2¼ : 1. These facts have been ascertained by experiments in which the income and expenditure of nitrogen and carbon were determined. They have likewise been confirmed by burning numerous foods and the single constituents of foods in a bomb calorimeter. When completely oxidized by combustion, each gramme of dry material gives out a measurable quantity of heat. The amount of heat given off by a known weight of substance is fairly constant, and is called the **heat value**, or heat of combustion. The heat value is expressed in calories; the term has been previously explained. For the purposes of this book, the large calorie, or kilcalorie, will be used whenever it is possible to do so, except in quotations from other writings. The bomb calorimeter is an instrument which will measure the heat developed during the combustion of substances within it. The heat of combustion of various substances, as determined by the bomb calorimeter, is given in the following tables:

The Heat of Combustion of Proteins.[1]

Vegetable Proteins :	Calories per Gramme.	*Other Nitrogenous Bodies :*	Calories per Gramme.
Legumin	5·783	Leucin	6·525
Fibrin	5·672	Tyrosin	5·916
Albumin (pumpkin-seeds)	5·595	Sarcosin	4·506
Animal Proteins :		Creatin: Anhydrous	4·275
Syntonin	5·908	Crystallized	3·714
Elastin	5·961	Aspartic acid	3·899
Chondrin	5·131	Guanin	3·829
Ossein	5·040	Glycocoll	3·050
Serum-albumin	5·918	Caffein	5·232
Paraglobulin	5·634	Uric acid	2·750
Fibrin of blood	5·508	Urea	2·542
Hæmoglobin	5·885		
Casein	5·858		
Egg-albumin	5·735		
Egg-vitellin	5·745		
Peptone	5·299		

The Heat of Combustion of Carbohydrates.[2]

Substance :	Calories per Gramme.	*Substance :*	Calories per Gramme.
Starch	4·325	Dextrose anhydride	3·939
Arrowroot (95 per cent. starch)	4·195	Hydrate	3·569
Cornflour (90 per cent. starch)	3·892	Dextrin	4·325
Cellulose	4·146	Maltose anhydride	4·163
Cane-sugar	4·173	Hydrate	3·932
Granulated sugar	4·561	Lactose anhydride	4·162
Powdered sugar	4·561	Crystallized	3·945

The Heat of Combustion of Fats.[2]

Animal :	Calories per Gramme.	*Vegetable :*	Calories per Gramme.
Beef fat	9·686	Olive-oil	9·455
Pork fat	9·423	Other oils	9·339-9·467
Butter fat	9·179	*Fatty Acids, etc. :*	
Other fats	9·3-9·45	Stearic acid	9·717
Fatty Substances :		Butyric acid	5·647
Mutton suet (95 per cent. fat)	8·730	Acetic acid	3·505
Beef suet (82 per cent. fat)	7·809	Succinic acid	2·996
Pork fat (84·5 per cent. fat)	8·550	Tartaric acid	1·407
Lard (100 per cent. fat)	9·303	Oxalic acid	·659
Butter (85 per cent. fat)	7·925		

The Heat of Combustion of Alcohol.

Absolute alcohol .. .. 7·100 calories per gramme.[2]

[1] These figures are from reports by Stohmann and Langbein, *Jour. f. Prakt. Chem.*, 1891, xliv. 336, excepting that, for the sake of uniformity, small calories have been made into large ones.

[2] These figures are from reports by Stohmann, Langbein, von Richenburg, Atwater, and Bryant. Where necessary, the figures have been made into large calories.

Heat produced in the Body by Food.—All non-nitrogenous foodstuffs, when completely digested, yield in our bodies the same amount of heat as in the calorimeter, the final products being the same. But the case of nitrogenous foodstuffs is different. Proteins are not completely oxidized in the body or reduced to the lowest grade of chemical composition. They are, moreover, split into a nitrogen-moiety and a carbon-moiety. The carbon-moiety is as completely oxidized in the body as in the calorimeter. The nitrogen-moiety is not reduced to ammonia and water, the ultimate products of nitrogenous decomposition, but it is excreted as an organic compound, which in man is chiefly urea, and a smaller proportion of quaternary compounds (here called "meat bases"), which have a recognizable heat value. The calorific value of these excretory products, therefore, must be subtracted from the full heat value of nitrogenous foodstuffs as ascertained by the calorimeter; the balance only represents the energy actually yielded to the body, and it is known as the "physiological heat value." It may be stated as a general rule that each gramme of protein consumed results in the excretion of $\frac{1}{3}$ gramme of urea. Therefore, to ascertain the heat value of protein in the body, we must subtract from the figures given in the table one-third of the heat or equivalent of urea: $\frac{2 \cdot 542}{3} = 0 \cdot 818$ calorie; and for the small proportion of uric acid and other nitrogenous substances we may allow 0·18 calorie, and subtract 1·0 large calorie from that given by the calorimeter. It is thereby ascertained that the energy or heat value of protein is little more than that of carbohydrates. Indeed, the heat value of carbohydrate foods is not quite the same as that determined by the calorimeter, and, with both protein and carbohydrate foods, depends upon the digestibility of the food or the amount of residue in the fæces. But as a store of energy, it may be considered that proteins and carbohydrates are of about equal value, the fats having about double the energy-producing capacity of the other two. The consideration of a large number of estimations of the heat produced in the calorimeter and of the digestibility of various foods led Rubner[1] to fix their value approximately as follows (these figures are accepted by many observers as being fairly accurate, and they have passed into common use):

Average Heat-Value of 1 Gramme of Substance.	Large Calories.
Protein	4·1
Fat	9·3
Carbohydrate	4·1

The experiments of Rubner on animals also show that, as regards heat and energy, the various foods may replace each other in exact ratio to the energy derived from them; thus, 100 grammes of fat are isodynamic with 225 grammes of syntonin, 243 grammes of dried

[1] *Zeit. f. Biol.*, 1885, xxi. 250-257.

muscle, 232 grammes of starch, 234 grammes of cane-sugar, and 256 grammes of dextrose. That is to say, in round numbers, 227 grammes of carbohydrate or protein are equal to or isodynamic with 100 grammes of fat, because they yield 930 calories on combustion in the body. This isodynamic law is of great value in problems of nutrition and metabolism. Rubner also found by experiment that the heat produced in an animal's body corresponds almost exactly (to within 0·47 per cent.) with the heat *calculated* from the above factors. The heat value of a large number of foods in common use is given in the Tables of Composition in the introductory chapter. These figures are sufficiently accurate for calculating dietaries for institutional or medical purposes. For making experiments in nutrition, the exact composition of the material in actual use should be determined by analysis. The factors of Rubner may then be used. But, in order to ascertain the *physiological availability* of energy, the food should be burnt in a bomb calorimeter, and the figure obtained will be the *gross* heat value; from this must be subtracted the heat yielded by the urine and fæces by combustion; and the *net* will show the physiological availability of the energy. Rubner[1] made many such experiments, and the following are examples of his results:

Food.	Heat lost per Cent.			Availability of Energy per Cent.
	In Urine.	In Fæces.	Total.	
Mixed diet: Poor in fat ..	4·70	6·00	10·70	89·3
Rich in fat	3·87	5·73	9·60	90·4
Meat diet	16·30	6·90	23·20	76·4
Cow's milk	5·13	5·07	10·20	89·4
Graham bread	2·40	15·50	17·90	82·1
Rye bread	2·20	24·30	26·50	73·5
Potatoes	2·00	5·60	7·60	92·4

In order to become oxidized in the system and yield heat and energy, the food must be capable of digestion and absorption. Herein lies the exact value of any food to the consumer. It was formerly considered that the measure of digestibility of any food was the length of time it remained in the stomach, and freedom from discomfort during that time. In a normal condition of health, digestion is unattended by any feeling save comfort after food. It is only under abnormal conditions that the presence of food in the alimentary canal gives rise to other sensation; it is then usually a pain referred to the stomach.

Observations upon the time many foods remain in the stomach were made by Beaumont on Alexis St. Martin, who had a gastric fistula. His experiments were accepted for many years by various authorities; but the science of nutrition has shown many errors in

[1] *Zeit. f. Biol.*, xlii.

his reasoning and conclusions. Within recent years observations have been made by other men with the object of ascertaining the length of time various foods remain in the stomach. Penzoldt made observations on gastric digestion in healthy men. He used a tube for removing the contents of the stomach for examination. He found that the amount and consistence of the food had a marked influence on the time it remained in the stomach. Fluids leave the stomach more rapidly than solids. Seven ounces of water or other common beverages leave the stomach during the course of half an hour. Hot drinks do not leave quicker than cold ones, nor does the quantity imbibed appear to have much effect on its passage. Solid matters in solution or suspension delay the passage of the fluid somewhat; thus, 7 ounces of milk occupied two hours in its passage through the stomach. The consistence of other foods had a similar effect. Indeed, the consistence appears to have a greater effect than quantity in delaying the transit of the food; the quantity necessarily influences the time occupied in gastric digestion and passage of the food through the pylorus, but the time so occupied is not proportionate to the amount. The table on pp. 40, 41, is compiled from various sources.

The Proportion of Food absorbed.—Although the length of time a food requires to pass through the stomach is a valuable criterion of the ease or difficulty of its digestion, it would be a mistake to consider as " indigestible " all those foods which occupy the stomach for a longer time than others, or that they should be avoided by healthy people. On the other hand, this criterion is of decided value in cases of ill-health and in dyspepsia, if the processes of digestion are delayed or inefficient. The test of time occupied by its passage through the stomach refers only to the " apparent digestibility," while the test of " actual digestibility " is the amount absorbed. It has been truly said: " We live not upon what we eat, but upon what we digest." The term "digestibility," therefore, refers to the entire process of digestion, and not merely to that which occurs in the stomach. In this sense a " digestible food " is one of which the largest possible percentage is absorbed, and an " indigestible food " is one of which a considerable portion passes out of the system in the fæces, without being disintegrated and absorbed. The mode of determining the " actual digestibility " of a substance is as follows: (*a*) The total amount of the food consumed is noted, and the total amount of protein, fat, and carbohydrate, is either determined by analysis of the food or by calculation from tables of composition. (*b*) The total weight of the fæces afterwards excreted is ascertained, and the amount of nitrogen, fat, and carbohydrate, therein determined by analysis. (*c*) The difference in the consumption and the residue in the fæces is, roughly speaking, the amount digested and absorbed. To obtain the fæces from a particular meal or meals, the consumer takes some blackberries, charcoal, or other substance, a few hours before the food whose digestibility is being tested, in order to make a dividing line between

it and previously consumed food. The actual amount of nitrogen and fat in the fæces is not quite all derived from the food, since there is always a small amount of nitrogen therein arising from metabolism in cells of the mucous membranes, from enzymes and bacteria.

Nitrogen in Fæces due to Metabolism.—Fæces consist of the undigested residue of the food, mucus from the walls of the intestines, epithelial cells, bacteria, colouring matter, cholesterin, salts of the fatty acids, bile, and other substances. It cannot, therefore, be contended that all the nitrogen in the fæces is derived from the food or from unmetabolized matter. That which comes from bile, mucus, and the débris of epithelial cells, has been metabolized, and formed a part of the nitrogenous material of the organism. It consists, in a way, of nitrogen which is accidentally lost. If no food is consumed, bile and mucus are still secreted, the epithelium continues to shed its cells, and bacteria flourish, and are expelled with the fæces. Reider carried out experiments on a man with *food free from nitrogen*, which he ascertained to be well digested. The food consisted of a cake made of starch, sugar, fat, and a little salt, leavened with cream of tartar and bicarbonate of soda; a little white wine and water were the only beverages; they were also free of nitrogen. It was consumed in sufficient quantity to secure a normal secretion of the digestive juices. Under these circumstances, it was assumed that any nitrogen in the fæces would arise from metabolic processes only. The average amount of nitrogen in the fæces during the experiment was 0·5 gramme per diem, and the conclusion is that this figure fairly represents the amount of nitrogen in the fæces arising from metabolism, and that anything above that amount is due to residues from the food.

The total amount of nitrogen excreted in the fæces daily is normally 1·39 grammes; and the amount of nitrogen in the fæces, less 0·5 gramme from metabolic products, is the measure of the indigestibility of the food or of the patient's inability to digest and absorb it. The larger the amount of nitrogen in the fæces, the less completely has the food been absorbed in the alimentary canal. It varies with the diet, being less on milk and eggs, and greatest on a purely vegetarian diet. Thus, with 4·5 litres of milk, containing 24·3 grammes of nitrogen, 21·7 grammes reappeared in the urine, and only 1·1 grammes in the fæces, the body retaining 1·5 grammes. With a diet of peas, beans, bread, butter, and meat extract, containing 21 grammes of nitrogen, 15·5 grammes reappeared in the urine, 4·9 grammes in the fæces, and 0·6 gramme was retained by the body. But, given the same food regularly, the individual normally excretes the same amount of nitrogen daily in the fæces. This rule with regard to protein absorption is therefore established: The nitrogen in the fæces (minus 0·5 gramme per diem) represents the residue of undigested protein in the food; and the nitrogen in the food less that in the fæces (minus 0·5 gramme) is the measure of digested protein of the food.

The amount of fat digested is usually calculated as fat in the food minus the ether extract in the fæces. This is substantially correct,

THE TIME OCCUPIED BY GASTRIC DIGESTION.

Kind of Food.	Quantity of Food.	Time in which the Food left the Stomach.	Authority.
Beef	3½ ounces of raw beet	2 hours	
	,, of half-boiled beef	2½ ,,	
	,, of boiled beef	3 ,,	
	,, of half-roasted beef	3 ,,	
	,, of roasted beef	4 ,,	
Mutton	3½ ounces of raw mutton	2 ,,	
	,, of half-boiled mutton	2½ ,,	
	,, of boiled mutton	3 ,,	Jessen (*Zeit. f. Biol.*, 1883, xix. 129).
	,, of half-roasted mutton	3 ,,	
	,, of roasted mutton	4 ,,	
Veal	3½ ounces of raw veal	2½ ,,	
	,, of boiled veal	3¾ ,,	
	,, of roasted veal	5 ,,	
Pork	3½ ounces of raw pork	3 ,,	
	,, of boiled pork	4½ ,,	
	,, of roast pork	6 ,,	
Sweetbread	9½ ounces of cooked sweetbread	2¾ ,,	
Chicken	8¼ ounces of cooked chicken	3 to 4 hours	
Ham	6 ounces of boiled ham	3 to 4 ,,	Penzoldt (*Deut. Arch. f. Klin. Med.*, 1893, xli. 535).
Tongue	9 ounces of smoked tongue	4 to 5 ,,	
Goose	9 ounces of roast goose	4 to 5 ,,	
Fish	7½ ounces of fresh fish	2½ hours	
	7½ ounces of salt fish	4 ,,	Penzoldt (*loc. cit.*).
Oysters	10 raw oysters	2½ to 3 hours	

Eggs	2 lightly boiled eggs	$1\frac{3}{4}$ hours	Penzoldt (*loc. cit.*).
	2 raw eggs	$2\frac{1}{4}$,,	
	2 poached eggs + 5 grammes of butter	$2\frac{1}{2}$,,	
	2 hard-boiled eggs	3 ,,	
	2 eggs in omelette	3 ,,	
Milk	$\frac{1}{2}$ pint of raw milk	4 ,,	Reichmann and Verhaegen.
	,, of boiled milk	3 ,,	
	1 pint of raw milk	$3\frac{1}{2}$,,	Penzoldt (*Deut. Arch. f. Klin. Med.*, xix. 129).
	,, of skimmed milk	$3\frac{1}{2}$,,	
	,, of sour milk	3 ,,	
	,, of boiled milk	4 ,,	
Bread	$2\frac{1}{2}$ ounces of white bread	2 ,,	Penzoldt (*ibid.*, li. 535).
	$5\frac{1}{3}$,, of white bread	3 ,,	
	$5\frac{1}{3}$,, of brown bread	4 ,,	
Rice	$5\frac{1}{2}$,, of boiled rice	$3\frac{1}{2}$,,	
Barley	$2\frac{1}{2}$ ounces of boiled barley	$3\frac{1}{2}$,,	
Tapioca	$1\frac{2}{3}$,, ,, tapioca	$2\frac{3}{4}$,,	
Lentils	$5\frac{1}{3}$,, ,, lentils. mashed	4 ,,	
Dried peas or beans	$7\frac{1}{2}$,, ,, peas or beans	$4\frac{1}{2}$,,	
French beans (string beans) ..	$7\frac{1}{2}$,, ,, kidney beans	$4\frac{1}{2}$,,	
Potatoes	$5\frac{1}{3}$,, ,, potato	2 to $2\frac{1}{2}$ hours	Rubner.
Carrots	$5\frac{1}{3}$,, ,, carrots	$3\frac{1}{2}$ hours	
Cabbage	$5\frac{1}{3}$,, ,, cabbage	4 ,,	
Cauliflower	$5\frac{1}{3}$,, ,, cauliflower	$2\frac{1}{4}$ to 3 hours	
Spinach	$5\frac{1}{3}$,, ,, spinach	3 hours	
Radishes	$5\frac{1}{3}$ ounces of raw radishes	4 ,,	
Apples	$5\frac{1}{3}$,, ,, ripe apples	$3\frac{1}{4}$,,	
	$5\frac{1}{3}$,, ,, unripe apples	4 to 6 hours	
Cherries	$3\frac{1}{2}$,, ,, ripe cherries	2 to 3 ,,	

as very little fat except cholesterin leaves the body unmetabolized when once it has been absorbed. *The amount of carbohydrate absorbed* is also calculated as that in the food minus that in the fæces.

There is, however, another method of determining the digestibility of foodstuffs—viz., by artificial digestion. Stützer elaborated the system of artificial digestion to such an extent, with regard to proteins and carbohydrates, that he was able to ascertain their digestibility with results agreeing almost exactly with observations which included the actual consumption of the foodstuff and subsequent examination of the fæces. Pfeiffer confirmed many of these experiments by the former method. It is much simpler, but is not quite so reliable.

Animal food is more completely absorbed than vegetable food, as shown by the difference between nitrogen in food and in fæces. Only a small proportion of protein in meat remains unabsorbed, but there is twice that amount left from milk, and a very much larger amount from vegetables. The average percentage of **un-absorbed protein** from various foods is as follows: Beef, 2·65; eggs, 2·9; cheese, 3·8 (2·9 to 4·9); milk, 8·3 (6·5 to 12·0); bread—white, 22·4; wholemeal, 30·5; rye, 32·0.[1] Another authority found the unabsorbed protein from white bread 20·0; brown, 42·5; and rye-bread, 32·2.[2] Cereal flour, 9·4 (8·2 to 10·5); pea flour, bean flour, and lentil flour, 9·35; boiled lentils, 40·0.[3] Macaroni, 11·2; vermicelli, 17·1; maize, 10·5; rice, 20·4; potatoes, 32·2; carrots, 39·4; cabbage, 18·5; boiled peas, 22·25.[4] Broad beans, 30·25.[5] Peas and bread, 16·0.[6] Lentils, potatoes and bread together, 53·5.[7]

Proportion of Foods absorbed—Percentages (Rubner).

Nutrients digested.	Meat.	Eggs.	Milk.	Cheese.	Rice.	Potatoes.	Peas.	White Bread.	Black Bread.	Carrots.
Protein	97·5	97	92	97	80	75	80	78	68	80
Fat	80·0	95	95	95	—	—	—	—	—	—
Carbohydrate	—	—	—	—	99	92	95	99	88	82

These observations were extended and confirmed by Atwater and Benedict. When animal food predominates in a meal, 97 per cent. of protein—that is, the highest proportion—is digested. When carbohydrate foods predominate, the digestibility of the food is the same as on ordinary diet. When fats predominate, the digestibility of fat is at its highest.

1 Rubner, *Zeit. f. Biol.*, 1879, xv. 115; 1880, xvi. 119; 1883, xix. 63.
2 Meyer, *Zeit. f. Biol.*, 1871, vii. 1.
3 Strümpell, *Deut. Arch. f. Klin. Med.*, 1876, 108.
4 Rubner, *loc. cit.*
5 Prausnitz, *Zeit. f. Biol.*, 1890, xxvi. 227.
6 Woroschieloff.
7 Hoffmann.

INFLUENCE OF DIET ON ITS OWN DIGESTIBILITY—PERCENTAGES.

Kind of Diet.	Coefficients of Digestibility.				Availability of Energy.
	Protein.	Fat.	Carbohydrate.	Ash.	
Ordinary diet	92·4	94·5	97·9	77·3	90·5
Carbohydrate diet	89·1	94·3	98·2	72·3	92·7
Fat diet	90·6	96·7	97·0	67·4	91·7

Atwater and his co-workers made a considerable number of observations on digestion in healthy men. The food, urine, and fæces, were analyzed, and the heat of combustion of the food, urine, and fæces, was determined in the bomb calorimeter. From their observations they framed the following table:

COEFFICIENTS OF DIGESTIBILITY.

Source of Nutriment.	Protein.		Carbohydrate.		Fat.	
	Digested.	Calories.	Digested.	Calories.	Digested.	Calories.
	Per Cent.	Per Ounce.	Per Cent.	Per Ounce.	Per Cent.	Per Ounce.
Total foods in mixed diet	92	114·00	97	114	95	253·0
Animal foods in mixed diet	97	121·00	98	108	95	253·0
Vegetable foods in mixed diet	84	90·00	97	114	90	237·5
Meat and fish	97	121·25	98	108	95	252·5
Eggs	97	123·75	98	108	95	255·6
Milk, cheese, and other dairy produce ..	97	121·25	98	108	95	250·0
Cereals and sugar ..	85	109·37	98	116	90	237·5
Legumes, dried ..	78	97·00	97	115	90	237·5
Fruits	85	95·00	90	102	90	237·5
Vegetables	83	88·00	95	113	90	237·5

The Digestibility of Meat.—Meat is one of the most digestible foods. As a general rule the residue from digested meat may be reckoned as 5 per cent.; 97 per cent. of protein and 98 per cent. of fat are absorbed. Roast chicken and veal are very tender, easily masticated, quickly disintegrated in the stomach, and pass into the intestines. Meat does not generally throw a great strain on the mechanical resources of the stomach. Mutton is digested quicker than beef, and pork slower than either; lean meat quicker than fat meat, and the flesh of young animals quicker than old ones. Cooking softens the tissues and favours digestion; but raw meat and underdone meat are digested somewhat quicker than

cooked meat. Hanging the meat for a few days or a week favours digestion, by allowing time for the lactic acid to soften the sarcolemma of the fibres. Smoked meat is digested rather quicker, and canned meats slower, than fresh meat. Chicken digests quicker than beef or mutton, because there is an absence of fat, the muscular fibres are shorter, the sarcolemma thinner, and the collagenous substances softer.

The Digestibility of Fish.—Long experience in prescribing for sick persons and invalids has resulted in placing in the following order the kinds of fish most suitable for them as regards apparent digestibility: Whiting, sole, plaice, flounder, fresh haddock, turbot, and cod. This order has been determined empirically. Whiting is well adapted for a weak stomach on account of the laxity of its fibres; haddock resembles it, but is firmer in texture; sole and plaice are tender, and their fibres are short and easily disintegrated; turbot has more flavour, but is easily digested; cod has a denser fibre, and forms a line of division between light fish and those heavier and fatter kinds which are suitable for robust and healthy persons. Salmon, trout, halibut, mackerel, herring, shad, conger-eels, etc., contain more fat, possess firmer fibre, and are not so easily digested. Chittenden and Cumming found that fish in general is not digested so easily as meat, although several kinds are digested as easily as lamb or mutton; they found fat fish less digestible than lean, with the exception of mackerel, which was quickly dissolved; but cod, which contains little fat, was the least digestible fish examined by them. German observations showed that white-fleshed fish, oysters, and shellfish, leave the stomach in three hours—that is, in the same time as eggs, milk, and white bread; salt herrings left the stomach in four hours—that is, in the same time as roast beef, goose, smoked tongue, boiled peas, and lentils. According to Penzoldt, smoked fish is digested more rapidly than unsmoked fish, owing to the condimental effect of the flavour. A comparison of the amount of protein and fat in fish consumed with that in the fæces shows that 97 per cent. of the protein and 90 per cent. of the fat, or a total of 95 per cent. of the fish, was absorbed. Those kinds of fish which contain a fair proportion of fat, such as the salmon and mackerel families, tunny, ling, and halibut, have a superior energy value, require a longer time for digestion than lean fish, and are a very efficient source of protein and energy for working men.

The Digestibility of Fat.—The undigested fat of the food is estimated as the ether extract from the fæces. Atwater found that 95 per cent. of fat from all animal foods was absorbed, but only 90 per cent. from vegetables. Rubner found only 80 per cent. of fat from beef, mutton, or horseflesh, was absorbed. Butter is well absorbed, the residue being only 2·7 per cent. when 8½ ounces were consumed daily. Bacon is not quite so well absorbed, because the fat is enclosed in cells; from 7·5 to 17·4 per cent. escapes absorption. Butter, lard, margarine, and cod-liver oil, being free from cell-

membranes, are almost completely digested. The fat of beef and mutton is more difficult of digestion, because it is enclosed in cells, and the surface tension of its globules is greater than in other fats.

The Digestibility of Eggs.—The absence of fibrous tissue and tough cellular membranes affords to eggs a digestibility which is unsurpassed, and is only equalled by a few foods, such as milk and oysters. Raw eggs are so bland that they make practically no demand on the stomach, neither vigorously exciting gastric secretion nor stimulating movement; in fact, they lie in the stomach rather longer than soft-boiled eggs, and escape into the duodenum very little altered. In the case of a man with a fistula near the pylorus, Bursch found that when raw eggs were taken by the mouth, quite half the substance passed through the pylorus unchanged. Penzoldt found that two raw, poached, or lightly boiled eggs leave the stomach in from two to three hours—*i.e.*, in the same time as milk, oysters, light fish, and white bread. Hard-boiled eggs lie in the stomach longer, because the albumin is coagulated, and far more resistant than in the semifluid raw or soft egg. In *artificial* digestion experiments, hard-boiled eggs require eight hours for complete digestion, whereas soft-boiled eggs are completely digested in six and a half hours, raw eggs in four and a half hours, and whipped raw eggs in four hours. But the mode of cooking has no other effect on digestibility than to prolong the time; for they are as digestible as meat; an examination of the fæces after eating hard-boiled eggs showed that 95 per cent. of the total dry substance, including 97 per cent. of protein and all the fat, was absorbed. Eggs fully deserve the high position in which they are placed by physicians and physiologists.

Eggs are usually innocuous; but, owing to some idiosyncrasy, they are injurious to some persons by causing pain, cramp at the stomach, vomiting, or diarrhœa. It is not known what these effects are due to, but it has been thought that they may be due to the decomposition of lecithin into cholin, etc. Anybody may be made ill by an excess of eggs, but the people referred to here are ill after consuming only a spoonful or two of an egg which is quite fresh. Neither are these symptoms due to ptomaine poisoning; the latter is due to the formation of toxins by the entrance of putrefactive bacteria through the pores of the shell. Such poisoning is more likely to occur after the consumption of confections such as ice-cream, éclair, custard, or cake. *Raw* white of egg is used to a considerable extent in cookery, and, when combined with milk and sugar, forms an admirable culture medium for bacteria. The yolk of egg is less likely to cause serious trouble, because it is more often cooked. Eggs are influenced by food which the fowl consumes, and they are liable to contamination by typhoid and other pathogenic organisms.

The Digestibility of Milk.—Although one of the most completely digested of foods in a mixed diet, milk is not quite so completely digested as meat or eggs. When milk is the sole food (*milk diet*), the proportion digested depends on the amount consumed; thus,

with a consumption of 3½ pints daily the loss of milk solids varies from 5·7 to 7·5 per cent.; and with 5 pints daily the loss by non-digestion of milk solids varied from 10 to 11·16 per cent. Atwater found milk better digested when it is part of a mixed diet; when consumed alone, the proportion digested was—Protein 92·1, carbohydrate 86·3, and fat 92·8, per cent. When milk and bread formed the diet, the amount digested was—Protein 97·1, carbohydrate 98·7, and fat 95·0, per cent.

Young children digest milk more completely than adults; up to four years of age the loss of protein by non-assimilation is only 4·5 per cent., but in healthy adults the loss may be 11 per cent., and more in a dyspeptic person. The fat absorption, too, varies with age; Camerer found that up to ten or twelve years of age the loss in the fæces was 2·8 per cent., and in adults Rubner found a loss of 4·6 to 7·2 per cent. of fat. Sterilization of milk slightly lowers its digestibility; Listov found the quantitative metabolism of sterilized milk was 91·8 per cent., and of raw milk 93·6 per cent.

The Digestibility of Bread.—Bread is readily digested. White bread digests quicker than brown or black bread, and biscuits (crackers) quicker than either of them; this is probably due to a difference in the texture and size of the particles of flour, and is well shown in the following table by Snyder:

THE DIGESTIBILITY OF BREAD.

Quality of Flour.		Percentage absorbed.			Energy available, per Cent.
		Protein.	Fat.	Carbohydrate.	
White bread:	Standard patent flour	85·3	56·4	97·5	90·1
	First patent flour ..	90·5	—	98·0	92·8
	Second patent flour ..	91·4	—	98·7	93·5
Brown bread:	Entire wheatmeal ..	80·4	55·8	88·4	80·7
	Graham flour	77·6	58·0	88·4	80·7

Penzoldt's findings are given on p. 41. It was also found by Rubner that when 600 grammes (21¼ ounces) of bread were consumed daily the amount *undigested* equalled 4·0 per cent. of the dry substance of white bread, 6·6 per cent. of second quality (baker's grade), and 12·23 per cent. of that in brown bread. The amount of best bread lost or undigested equalled 20·0 per cent. of the nitrogen, 44·7 per cent. of the fat, and 1·10 per cent. of the carbohydrate; in seconds bread the amount undigested contained 24·5 per cent. of the nitrogen, 63·8 per cent. of the fat, and 2·57 per cent. of the carbohydrate; in brown bread the undigested portion contained 30·0 per cent. of the nitrogen, 51·1 per cent. of the fat, and 7·37 per cent. of carbohydrate. These figures, and those in Snyder's table clearly prove that white bread made from first or second patent flour (patent grade and baker's grade) is superior as a source of

protein, carbohydrate, and energy. The difference of 10 per cent. in the available energy and digestible nitrogen settles the question of brown *versus* white bread in favour of the latter. The fact that brown bread contains a trifle more protein and fat is no proof of its superiority; on the other hand, the loss of 30 per cent. of nitrogen and 50 per cent. of the salts is quite against it; even **germ bread,** consisting of white flour with 7 or 10 per cent. of germ from other wheat, is no better than white bread, the amount digested being protein 90, carbohydrate 97·6, per cent.

With **rye bread** the loss of protein varies from 25 to 40 per cent.—*i.e.*, only 60 to 75 per cent. is digested; but the carbohydrates are well digested, and 85 per cent. or more of the total energy is available. Black bread made with **buckwheat** is even less easily digested than rye bread, because the seeds contain 11 per cent. of cellulose, and are on a par with dried legumes.

The Digestibility of Macaroni, Vermicelli, and Noodles.—These substances contain 11 to 13 per cent. of protein, 75 to 78 per cent. of carbohydrate, and only 0·35 per cent. of cellulose. They are eminently digestible, only about 4 per cent. of the dry substance escaping absorption, which includes 10 per cent. of the nitrogen. They are useful foods in stricture of the bowels and other diseases, where it is desired to have only a small residue of food.

The Digestibility of Maize, Oatmeal, Rice, Sago, and Tapioca.—The general rule for cereals is that 85 per cent. of protein, 90 per cent. of fat, and 98 per cent. of carbohydrate is absorbed. Corn starch, cornflour, sago, tapioca, and arrowroot, consist chiefly of starch, and are almost entirely absorbed. Maize-meal, oatmeal, rice, and millet, in general, follow the rule given above.

Maize is an important food of the peasantry in many parts of the earth. It is a very useful source of carbohydrate and fat, and the experiments of many observers show it is well digested. As regards nitrogen, it is somewhat deficient. Observations on the food of poor healthy peasants in Italy were made by Alberti and Vovi. In winter their diet consisted of polenta, soup, herrings, and fat, and the nitrogen balance was deficient to the extent of 1 gramme a day. In summer they ate bread, mutton, cheese, and fish, and they gained 5 grammes of nitrogen daily. Polenta is made of maize-meal, sometimes with chestnut-meal, and milk. The deficiency in the winter dietary was probably due to shortness of milk.

Oatmeal, barley-meal, and other cereals which are not ground very fine, do not digest so easily as wheatflour. But much depends on the mode of cooking. Oatmeal gruel is digested easier and more completely than oat-cake, but when it is consumed with a sufficiency of milk it forms a complete diet.

Millet, sorghum, and durra, staple foods of the peasantry in Oriental countries, are not digested easily; only 40 to 45 per cent. of the protein was absorbed in an observation made by Kurcheninov on three healthy persons. It is found, however, sufficient energy is derived from a diet in which millet predominates.

Rice is another cereal of great economic importance. It forms a staple food for millions of people. Ordinary polished rice contains only 0·5 per cent. of cellulose, and almost all the substance of the grain is absorbed, including all the carbohydrate and 80 to 81 per cent. of the protein. As a food for invalids it possesses a high value on account of its digestibility. The starch granules are exceedingly small, and readily transformed into sugar. It is absorbed chiefly in the upper bowel, and very little residue reaches the colon. This makes it of immense value in intestinal diseases, where it is desirable to have little residue from the food.

Sago, tapioca, and arrowroot are also very digestible; they contain very little protein and fat, and 98 per cent. of the carbohydrate is absorbed. These root starches are digested more quickly than the cereal starches. In some artificial digestion experiments Grierson found the time required for complete digestion of wheat, maize, and rice was two hours; oatmeal, eighty minutes; tapioca and sago, thirty minutes; arrowroot and potato starch, ten minutes. Penzoldt found, however, that a gruel made of 1½ ounces of tapioca did not leave the stomach entirely in less than two and three-quarter hours; but this quantity, it should be observed, would make a large pudding, and be far more than any person would take at an ordinary meal. Grierson concluded from his experiments that, for persons with weak digestion, *tous les mois*, arrowroot, and potato purée are the best carbohydrates, and after these tapioca and sago. Puddings made of these substances usually contain milk, sugar, and butter, which add considerable protein and fat to the mixture. They are usually well and easily digested, are fairly well balanced and typical representative foods, suitable alike for invalids, the aged, and children.

The Digestibility of Legumes.—Leguminous seeds justly occupy a high position as a source of proteins. Judging by analysis alone, they contain more of these principles than the best cuts of meat. A generation ago Moleschott pronounced them to be " true treasure-houses for the renewal of our blood, peas being equal to veal, beans to poultry, while lentils leave every kind of meat far behind." But it is questionable if any individual could consume enough of them daily to supply the needs of the organism.

Peas have been investigated by many men. Rubner found that 1¼ pounds (600 grammes) of dried peas would be required daily to maintain the nitrogen balance in equilibrium, and 2 pounds (960 grammes) to supply energy. When 2 pounds were consumed, 72 per cent. of protein, 25 per cent. of fat, and 93 per cent. of the carbohydrate were absorbed; when 1¼ pounds were eaten, 83 per cent. of the protein, 36 per cent. of fat, and 96 per cent. of carbohydrate were absorbed; the loss of protein, therefore, was from 17 to 28 per cent., although the peas were well cooked and *rubbed through a sieve.* Most observers agree with these findings, but Strümpell gave the opinion that the digestibility depends on the kind of water used in cooking, and stated that the calcium and

magnesium salts of hard water form insoluble compounds of protein which are not easily dissolved in the digestive secretions. Richter confirmed this experiment by finding that, when 600 grammes of peas were consumed after boiling in distilled water, 90 per cent. of protein and 88 per cent. of fat were digested. This suggests that carbonate of soda used in cooking might neutralize the effect of calcium and magnesium salts, and that rain water would entirely prevent it. Moreover, the loss of protein is not so great when peas form part of an ordinary mixed diet—*e.g.*, pea soup. In such a case Strümpell found only 8 or 9 per cent. remained undigested after the consumption of 7 ounces (200 grammes) of dried peas.

Beans have about the same digestibility as peas. Prausnitz fed $1\frac{1}{4}$ pounds of cooked white navy beans to a man for three days in succession, and found 15 per cent. of the total dry matter, including 30 per cent. of the protein, was not absorbed. Oshima experimented with dried soya beans, and found 35 per cent. of the protein unabsorbed.

Lentils vary in digestibility according to the mode of cooking. Strümpell tried them on himself, and found, when he consumed 7 ounces a day, 40 per cent. of the protein reappeared in the fæces. When they were ground to flour and consumed as part of an ordinary meal, only 10 per cent. of protein escaped digestion. Hard water interfered with their digestion, and distilled water favoured it.

As part of a mixed diet, all kinds of legumes are better digested than when they are consumed alone. Wait records a number of observations on mixed diet, and found 80 to 90 per cent. of the protein of peas was digested. Snyder also found that 80 per cent. of protein and fat, and 96 per cent. of the carbohydrate, were absorbed from white navy beans.

The Digestibility of Vegetables.—Vegetables are less easily digested than animal food, because the material is enclosed in cells composed of cellulose, which prevents the digestive secretions getting access to the nutrients; moreover, vegetable foods are prone to fermentation, which increases peristalsis and hurries them along the canal before they have time to be absorbed; even the cellulose adds to this effect by acting as a local irritant.

Potatoes.—In European countries potatoes rank next to bread. This arises from the easiness of their digestion. Observations have shown that $5\frac{1}{3}$ ounces (150 grammes) of potatoes, boiled and eaten in the usual way, pass through the stomach in two to two and a half hours. Mealy potatoes digest quicker than waxy ones, and mashed quicker than unmashed ones. From 92·5 to 95 per cent. of the starch, the chief ingredient, is absorbed; but there is a loss of 23 per cent. of protein. The loss of nitrogen is of little account in a mixed diet; the quantity in the tubers is very small, and half of it is amide—*e.g.*, asparagin. The amide-nitrogen is of no nutritive value, but it is a stimulant to enzyme action, a disinfectant, and promotes the absorption of proteins and carbohydrates.

As regards economic value, potatoes are not suitable for the sole

food of people, owing to the deficiency in protein and fat. According to Atwater, 7 pounds of potatoes would contain 80 grammes of protein and yield 3,080 calories of energy, and, when absorbed, would be enough for a woman or man without work. But, as 23 per cent. of the protein is lost, there is a marked deficiency of nitrogen. The bulk of such a diet would be too much for most people; but with a combination of milk, butter, and eggs, the quantity could be reduced. Snyder found 3½ pounds of potatoes, eight eggs, 1 pint of milk, and a little cream, would afford an adequate dietary and give a slight gain of nitrogen to the body.

Carrots, Turnips, Parsnips, and Beetroots, are chiefly of value for their fresh juice containing mineral salts. The nitrogen is small. For instance, beetroot contains only 2 per cent., including 0·66 of protein-nitrogen, 0·58 of amide-nitrogen, and 0·76 per cent. as ammonia and nitrates. The protein in beetroot $= 0{\cdot}66 \times 6{\cdot}25 = 4{\cdot}12$ per cent., the carbohydrates 15 to 18 per cent., and cellulose 3 per cent. Carrots and parsnips contain 10 per cent. of sugar, but turnips have only 5 per cent. carbohydrate, chiefly pectose. When cooked, these roots lose half their soluble contents, and the remainder is neither quickly nor completely digested; 5½ ounces of boiled carrot required three and a half hours to pass out of the stomach, and only 61 per cent. of the protein, 79 per cent. of the carbohydrate, and 64 per cent. of the minerals, were absorbed.

Green Vegetables.—The composition of the common vegetables, both raw and cooked, is given in the introductory chapter. The protein is very small, and the fat, when most abundant, is objectionable and disturbs the digestive organs. The most important constituents are carbohydrates and salts. When boiled, all vegetables lose one-third of these constituents. Nevertheless, green vegetables are rightly held to be important articles of food. The salts of alkaline earths and metals supply the body with elements essential to the maintenance of sound health. Common experience shows that abstinence from them tends to various blood and skin diseases. Their digestibility depends largely on the amount of cellulose. In young rapidly-growing plants this is small, and they are digested well and easily. In slow-growing plants there is much more cellulose, some cells being coated with ligno-cellulose, which renders them useless to the human body.

Fruit and Nuts.—Very few observations have been made on the digestion of fruit alone, but there are many on fruit and nuts. Beaumont found that uncooked sour apples require two hours to pass through the stomach, and ripe sweet apples one and a half hours. Another observer found 5 ounces of raw ripe apples passed out of the stomach in three hours, but unripe ones required a much longer time. These may be taken as a fair sample of the digestion of fruit in the stomach. Cooking softens the cellulose and gums, and some of the pectose assumes a gelatinous form, whereby cooked fruit is able to pass out of the stomach more easily than raw fruit. Little is known of the length of time required for digestion of fruit

THE DIGESTIBILITY OF FRUIT AND NUTS.

Kind of Food.	Food consumed, Grammes.			Food digested per Cent.			Energy available per Cent.	Nitrogen Balance, Grammes.			
	Protein.	Fat.	Carbo-hydrate.	Protein.	Fat.	Carbo-hydrate.		Food.	Urine.	Fæces.	Gain or Loss.
Olives, grapes, tomatoes	13·75	23	222	44·43	67·76	95·84	86·35	2·20	4·67	1·22	− 3·69
Brazil nuts, grapes	53·12	142	199	84·17	91·20	95·06	88·72	8·50	4·69	1·35	+ 2·46
Brazil nuts, granose	66·61	86	383	85·44	84·32	97·45	89·01	10·66	5·47	1·55	+ 3·64
Walnuts, grapes, granose ..	53·87	116	214	79·76	89·48	97·18	88·18	8·62	8·59	1·74	+ 1·29
Peanuts, persimmons, granose, and milk	93·74	121	256	86·80	88·70	91·22	84·76	15·00	7·40	1·98	+ 5·62
Walnuts, pears, milk, and granose	71·65	133	342	84·10	91·41	96·98	89·12	11·46	5·39	1·82	+ 4·25
Cocoanut and pears	35·48	149	340	75·12	91·27	97·44	91·06	5·68	5·84	1·41	− 1·57
Walnuts, figs, apples	64·20	110	382	70·79	88·22	97·85	87·87	10·27	5·99	3·00	+ 1·38
Peanuts, dates, apples	77·83	104	383	78·14	83·29	97·16	86·70	12·27	7·41	2·70	+ 2·26
Peccans, dates, apples	47·48	110	465	76·16	91·53	97·78	91·88	7·60	5·83	1·81	− 0·05
Walnuts, raisins, apples ..	68·50	91	500	80·70	87·10	98·28	90·78	10·96	5·64	2·12	+ 3·20

in the bowels, but there is evidence to show that they are digested to the extent of 75 per cent. of protein, 86 per cent. of fat, 95 per cent. of carbohydrate, 78 per cent. of the woody fibre, 54 per cent. of ash; and 86 per cent. of the energy is available. The carbohydrates form the chief nutriment in fruit, and 75 per cent. of it is a mixture of dextrose and lævulose; the rest consists of starch, dextrin, gum, pectin, and pentosans, the latter being more or less transformed into pentose sugars during ripening. The salts are organic acids in combination with potassium, sodium, and earthy salts, which are transformed chiefly into alkaline carbonates in the alimentary canal. The aperient effect of fruit is due to the local action of the organic acids, and partly to the cellulose.

Nuts are a valuable source of protein and fat, but they are not so easily and completely digested as fruit, because a dense network of cellulose pervades the kernel. They are more difficult of mastication, and the cellulose prevents the access of digestive ferments to the materials in the cells. Their digestibility and availability is shown in the table on p. 51.

CHAPTER III

METABOLISM

Life consists, as far as material phenomena are concerned, in the transformation of matter and energy. To these transformations the term **metabolism** is applied. In the metabolism of matter the changes are chemical; in energy the changes are physical. It is commonly assumed that the laws of conservation of matter and energy are conformed to or obeyed in animal bodies. This has not been demonstrated to universal satisfaction, but a gradual approach to such demonstration has been made in recent years. The body can neither create nor destroy matter, and whatever energy it receives is apparently given off or retained without diminution.

It would be impossible here to go into a history of the science of nutrition. As early as the seventeenth century it was believed food is to the body what coal is to a fire; but it was not until 1789 that Lavoisier enunciated the process of oxidation and declared combustion in the animal organism is similar. The study of metabolism was much enlarged by Liebig, who made many observations. Much good work has since been done by a long list of workers.

The body converts potential into kinetic energy by metabolism in the body. The potential energy of the food is transformed into the actual energy of heat and mechanical labour. In this respect there is no difference between man and other vertebrates; the details may vary, but the end-products are the same. The only difference is in the nervous and intellectual processes, which is not yet understood.

Metabolism is anabolic and katabolic. *Anabolism* is constructive; it includes growth and the act of the tissues in selecting, appropriating, and making substances absorbed from the alimentary canal a part of themselves. The body is never stable; while growth and nutrition progress, destruction or demolition is taking place, and this is called *katabolism*. To ascertain the exact amount of matter and energy used daily by the body, a balance-sheet of the exchange of material is necessary. The **income** consists of—(*a*) *Matter*: Food, drink, and oxygen of the air. (*b*) *Energy*: The potential energy of the food and drink. The **outgo** consists of—(*a*) *Matter* in the urine, fæces, perspiration, and breath. (*b*) *Energy*: The potential energy of fæces, urine, products of respiration and perspiration. A complete account would show the amount of

C, N, H, O, P, S, Cl, Na, K, Ca, Mg, and Fe, in the income and outgo; it would also show the compounds in the excreta, including proteins, fats, carbohydrates, water, and CO_2. Two notable examples of observations are given—the first by Ranke, and the second by Pettenkofer and Voit—in the following table:

EXCHANGE OF MATERIAL WITH STANDARD DIETS.

Income.				Expenditure.			
Food.		Nitrogen.	Carbon.	Excretions.	Nitrogen.	Carbon.	Water.
	Grammes.	Grammes.	Grammes.		Grammes.	Grammes.	Grammes.
Protein	100	15·5	53·0	Urine ..	14·4	6·16	—
Fat ..	100	—	79·0	Fæces ..	1·1	10·84	—
Carbo-hydrate	250	—	93·0	Respiration (CO_2)	—	208·00	—
Total		15·5	225·0	Total	15·5	225·00	—
Protein	137	19·5	315·5	Urine ..	17·4	12·70	1279
Fat ..	117			Fæces ..	2·1	14·50	83
Carbo-hydrate	352			Lungs ..	—	248·60	828
Water ..	2016						
Total		19·5	315·5	Total	19·5	275·80	2190

These results, now classical, have never been impugned; but the tables are not so complete as modern tables. Moreover, the results derived from the experiments are better, perhaps more exact, when the observation is made on a body in a respiratory calorimeter. Such a chamber has been used by many observers. But few have carried their experiments out with the completeness of those conducted by Atwater and his co-workers from 1897 to 1907, and his successors to the present time. In their observations a man is usually selected in a state of good health, whose digestion is normal, and who is not uncomfortable during confinement. A palatable diet is selected; it is well cooked, accurately sampled, and carefully analyzed. The quantity of nitrogen and carbon is such as to keep the body in equilibrium during work or rest, according to the condition to be observed. A preliminary digestion experiment is made for four days prior to the observation, and during that period any change deemed desirable in the food is made, until an equilibrium is established. During these preliminary days the man rests or works, as he will do in the respiratory calorimeter. A summary of some of the observations is given in the table on p. 55.

All experiments show that the body has considerable power of adapting the output of nitrogen to the income, and this power is exercised within very wide limits. The quantity of protein katabolized cannot be taken as an exact measure of the permanent

SUMMARY OF METABOLISM EXPERIMENTS.[1]

1. Income and Outgo of Nitrogen and Carbon.

Kind of Experiment—Subject—Duration.	Nitrogen: Grammes in—				Carbon: Grammes in—					Body: Gain +. Loss −, Grammes.	
	Food.	Fæces.	Urine.	Gain +. Loss −.	Food.	Fæces.	Urine.	Respiratory Products.	Gain +. Loss −.	Protein.	Fat.
(1) *Rest Experiments* :											
E. O. (9): Average of 33 days ..	18·8	1·2	18·5	−0·9	253·4	10·6	12·9	218·8	+11·1	−5·6	+18·4
A. W. S.: Average of 3 days ..	15·5	1·0	15·4	−0·9	215·2	9·0	10·8	217·4	−22·0	−5·6	−24·9
J. F. S.: (3) Average of 12 days ..	16·5	1·1	15·7	−0·3	250·0	9·7	11·6	207·8	+20·9	−2·0	+28·9
Average of 13 rest experiments ..	18·0	1·2	17·6	−0·8	249·7	10·3	12·4	216·1	+10·8	−4·8	+17·5
(2) *Work Experiments* :											
E. O. (2): Average of 8 days ..	19·5	1·9	17·3	+0·3	355·1	16·3	12·6	358·9	−32·7	+2·0	−44·1
J. F. S. (4): Average of 12 days ..	16·1	1·0	16·0	−1·0	327·7	10·2	11·2	330·4	−24·1	−6·1	−27·4
Average of 6 work experiments ..	17·2	1·3	16·4	−0·5	336·8	12·2	11·7	339·9	−26·9	−3·4	−33·0
Average of 19 experiments in rest and work	17·7	1·2	17·2	−0·7	277·2	10·9	12·2	255·2	− 1·1	−4·4	+ 1·6

2. Income and Outgo of Energy: Calories.

Heat measured in the above Experiments.	Heat of Food.	Heat of Fæces.	Heat of Urine.	Net Income: Material oxidized.	Net Outgo: Heat measured.	Difference between Income and Outgo.	
						Calories.	Per Cent.
(1) *Rest Experiments:*							
E. O. (9): Average of 33 days ..	2,541	116	145	2,280	2,272	− 8	−3·5
A. W. S.: Average of 3 days ..	2,480	100	126	2,304	2,279	−25	−1·1
J. F. S. (3): Average of 12 days ..	2,361	110	134	2,117	2,136	+19	+0·9
Average of 13 rest experiments ..	2,636	113	141	2,244	2,241	− 3	−0·1
(2) *Work Experiments* :							
E. O. (2): Average of 8 days ..	3,770	179	129	3,865	3,829	−36	−0·9
J. F. S. (4): Average of 12 days ..	3,491	113	127	3,539	3,540	+ 1	—
Average of work experiments ..	3,584	135	128	3,647	3,637	−10	−0·3
Average of all experiments	2,926	120	137	2,688	2,682	− 6	−0·2

[1] Bulletin 109, pp. 126, 127, U.S. Department of Agriculture.

demands of the body, nor as a measure of the average demand of a man doing work; but experiments show that the body requires a given quantity of energy-producing substance for sustenance, and something more to meet the demands for muscular work. In a rest experiment extending over forty-five days, the net income was 2,255 calories, and the net expenditure 2,250 calories; and during a period of light work extending over sixty-five days the net income was 2,690 calories, and the net expenditure 2,682 calories. The elimination of energy during forty-five days of rest was determined to be as follows: By radiation and conduction from the skin and lungs 1,669, in urine and fæces 31, in water evaporated from the lungs 550—total 2,250 calories; during twenty days of work the heat eliminated by radiation and conduction from skin and air in lungs 2,777, in urine and fæces 19, in water evaporated from lungs 1,126, by muscular work 234—total 3,656 calories.

The amount of carbon dioxide excreted by the body has always been considered a measure of the energy expended. Parkes found that a man of 150 pounds weight during rest gives off 15 cubic feet of carbon dioxide in twenty-four hours, and that the production of 1 cubic foot of gas by combustion involved the expenditure of 160 foot-tons of energy, and 15 cubic feet 2,400 foot-tons of energy, which is equivalent to about 1,560 calories. He found the excretion of CO_2 during rest was 0·62 cubic foot per hour, during hard work 1·66, and laborious work 2·75, cubic feet. Atwater and Benedict also found the elimination of CO_2 varied with the condition. During rest and fasting it averaged 676, rest with food 812, work with carbohydrate diet 1,820, work with fat diet 1,665, and work with mixed diet 1,475, grammes daily. According to Parkes's figures, the energy expended daily during rest was 1,600 calories, during moderate work 2,600, and during hard work 3,200, calories. Playfair obtained similar results. In more recent times Zuntz found the expenditure was as follows:

EXPENDITURE OF ENERGY.

During absolute rest	1,700	calories a day.
,, sedentary life	2,200 to 2,250	,, ,,
,, moderate work	3,000 to 3,250	,, ,,
,, hard work	4,000 to 4,500	,, ,,

The Respiratory Quotient.—The amount of oxygen utilized in the oxidative processes of the body is of great importance, and in experiments on metabolism should be carefully determined. In an observation on a man at rest and consuming ordinary diet for four days, Atwater and Benedict found the total income of oxygen in food and drink was 7,523 grammes; the total outgo was 10,712 grammes. The difference was 3,189·5 grammes, of which 433·7 grammes was contained in body substance consumed during the observation. This leaves 2,756 grammes of oxygen, or 689 grammes daily over and above the amount in food and drink, and represents the quantity received from the air.

The respiratory quotient is the most delicate test of the carbonaceous metabolism of the organism; it is the ratio of the CO_2 exhaled to the oxygen consumed. It varies with the diet and rest or work. These facts are shown in the following table from experiments by Atwater and Benedict:

EFFECTS OF FOOD AND WORK ON RESPIRATION.

Conditions.	Heat measured.	CO_2 exhaled.	Oxygen consumed.	Respiratory Quotient.
	Calories.	Litres.	Litres.	
REST: Fasting	2,197	342·2	473·6	·727
REST: Ordinary mixed diet ..	2,287	404·5	469·4	·862
MODERATE WORK:				
Fat diet	3,570	613·9	737·5	·832
Carbohydrate diet	3,699	655·1	757·1	·865
HARD WORK: Fat diet	5,128	856·6	1,058·9	·809
Carbohydrate diet	5,142	929·2	1,025·9	·906

The respiratory quotient is determined by dividing the CO_2 exhaled by the O_2 consumed; 1 litre of CO_2 weighs 1·9642 grammes, and 1 litre of O_2 weighs 1·4286 grammes, and the corresponding factors are $1 \div 1{\cdot}9642 = 0{\cdot}5091$, and $1 \div 1{\cdot}4286 = 0{\cdot}7$. The amount of CO_2 exhaled by a man in one experiment lasting several days was 3,248·3 grammes, and the oxygen consumed 2,755·9 grammes,

$$\text{Whence } CO_2 = 3{,}248{\cdot}3 \times 0{\cdot}5091 = 1{,}653{\cdot}7 \text{ litres.}$$
$$O_2 = 2{,}755{\cdot}9 \times 0{\cdot}7000 = 1{,}929{\cdot}1 \quad ,,$$
$$\text{and } \frac{CO_2}{O_2} = \frac{1653{\cdot}7}{1929{\cdot}1} = 0{\cdot}857, \text{ the respiratory quotient.}$$

The influence of food on the respiratory quotient has been studied by many men. There is always an increase of respiratory activity after meals, greater in proportion to the amount, and greatest about an hour after the heaviest meal. All substances rich in carbon increase the output of CO_2. A purely carbohydrate diet is only possible for a short period, but during that time the respiratory quotient rises to unity or nearly so. An excess of fat lowers the respiratory quotient, but increases the output of CO_2. Alcohol, tea, and ethereal oils, diminish the output of CO_2. In herbivora, living largely on carbohydrates, the oxygen consumed reappears chiefly in the excreta as CO_2, and the respiratory quotient is usually 0·9, or nearly unity. In carnivora, living chiefly on proteins and fat, more oxygen leaves the body in the form of water, and less as CO_2; consequently the respiratory quotient sinks, and is usually about 0·6 or 0·7. In hibernating animals the respiratory quotient sinks lower than in any other known condition, being frequently less than 0·5, because the animal lives almost entirely on its own fat. Rest causes a fall in the respiratory quotient to about 0·7 or 0·8, but muscular activity causes a great increase in the intake of

oxygen and output of CO_2, especially the latter, and the respiratory quotient rises to 0·8, or even 0·9.

The metabolism of nitrogen is usually measured by the amount of urea in the urine, taking into account the small proportion of uric acid and other nitrogenous bodies. In addition to this, an average of 0·5 gramme of nitrogen per diem is excreted in the fæces. Voit taught that all the nitrogen was excreted in the urea and fæces; but there are other excreta which contain it. An experiment on seven Europeans and five Malays by Eijkmann[1] showed that the amount of nitrogen in the perspiration varies with that excretion, but averages about 1 gramme per diem. Charles found perspiration contains urea, epithelial cells, and nitrogenous fats, and contained 0·08 per cent. of nitrogen.

The Effect of Fasting on Metabolism.—The organism lives on its own flesh and fat. In an experiment by Benedict on a man during seven days' fast, the loss was estimated to be—Protein 69·5, fat 139·6, glycogen 23, grammes, per diem, yielding 1,597 calories. The loss of protein corresponded to 347 grammes of flesh; the actual loss of energy measured by the calorimeter was 1,696 calories per diem, or 100 grammes more. The heat of combustion can be calculated from the known heat value of the substances, 1 gramme of body protein yielding 5·65 calories, and 1 gramme of fat 9·54 calories and the total when fully oxidized would amount to 1,734 calories.

The Effect of Nitrogenous Diet on Metabolism.—The most striking effect of a purely nitrogenous diet is a large increase in the nitrogenous metabolism, but it also increases the metabolism of the non-nitrogenous elements of the body. With an ordinary mixed diet the normal excretion of urea varies from 33 to 37 grammes a day, and with a meat diet the urea excretion may rise to 50 or even 80 grammes daily. From this circumstance Voit concluded that the proteins which increase the urea excretion are not really built up into the tissues, and he divided the proteins in the body into "tissue proteins" and "circulating or floating proteins." The former are those converted into cellular elements, and the latter speedily undergo metabolism and liberate their energy in the form of heat. The establishment of a nitrogenous equilibrium does not mean that the body neither gains nor loses weight. When the meal required to balance the nitrogen is a large one, although there may be no retention of nitrogen, the body may gain weight by laying on fat. The amount of fat stored up may be more than that consumed, and we are driven to the conclusion that in such a case the protein is split into a urea moiety and a fatty moiety, and that the urea moiety is mostly discharged as urea, while the fatty moiety is used as an energy-producer, or the excess stored up as adipose tissue. This disruption of the protein molecule explains the rise in nitrogenous excretion which constantly and proportionately follows the consumption of proteins.

It is not quite clear where the transformation of protein takes

[1] Virchow's *Archiv*, cxxxi. 170.

place. Burdon-Sanderson[1] said: "The production of urea and other nitrogenous metabolites is exclusively the function of living material." Michael Foster[2] and Hoppe-Seyler[3] say we can make no distinction between "tissue protein" and "floating protein." All proteins consist of amino-acids, and our knowledge of these has been increased in recent years. It is now considered that all proteins undergoing digestion are broken down to amino-acids in the alimentary canal, and reconstructed into proteins in the epithelial cells of the mucous membrane. Thence they are transported in the blood and lymph streams to cells all over the body, and these cells again break down the proteins to amino-acids, and out of these acids construct proteins to their own pattern. But all cells do not require the same kind or quantity of amino-acids. The surplus is thrown off, re-enters the lymph or blood stream, and is carried to the liver, where it is transformed into urea, giving off heat and energy in each stage of the downward course. The consumption of protein provokes metabolism in the living cells, and the more protein consumed, the greater will be the amount of urea excreted. It seems as if the cells, like gourmands, develop an appetite according to the supply, and the rapid exchange of material causes a corresponding output of nitrogenous waste.

It is possible for an excessive consumption of protein to lead to the storage of protein in the cells of the liver and other tissues, and this "stored protein," although enclosed in the cells, is not a part of the living protoplasm. "Tissue protein," on the other hand, is that which has become an integral part of the protoplasm of the cells. It is considered that stored protein is broken down with comparative ease, while tissue protein is much more stable.

When the food contains enough protein for the purposes of ordinary metabolism, very little tissue protein is broken down; in fact, the destruction of tissue protein which occurs in normal circumstances is represented only by the waste nitrogen arising from the breaking down and regeneration of cells. Even during fasting very little tissue protein is broken down. The proteins of the food and stored proteins are broken down very readily, while the organism makes every effort to protect tissue proteins from destruction. The tendency of the organism to metabolize only consumed proteins (stored proteins and food proteins) is chiefly noticeable when (1) the protein of the food is excessive, (2) the daily supply of nutriment is taken in several meals, (3) and during nutrition after fasting. In metabolism experiments, it is not enough to determine the income and outgo of nitrogen; the income and outgo of phosphoric acid must also be determined, and the ratio of phosphoric acid to nitrogen in the urine: for these factors alone show whether tissue proteins or food and stored proteins are broken

1 "Syllabus of Lectures," p. 37.
2 "Textbook of Physiology," p. 826.
3 "Physiol. Chem.," p. 974.

down. After repeated analyses, Kolpakcha[1] found the ratio of phosphoric acid to nitrogen and nitrogen to sulphur is as follows:

Substance.	P_2O_5 is to N.	S is to N.
Meat	1 : 7·3	1 : 15·6
Gelatin	nil	1 : 22·5
White of eggs . .	1 : 47·6	1 : 9·8
Yolk of eggs . .	1 : 1·8	—

As the ratio of these elements in the protein of foods differs, so the ratio of these elements in the urine will differ with the kind of food consumed and with partial or complete fasting. Kolpakcha found, when the body is in nitrogenous equilibrium, the ratio of P_2O_5 to N is the same in the urine as in the food; but when there is a deficiency of food the ratio alters, and in fasting—*i.e.*, when the body consumes its own proteins—the ratio of P_2O_5 to N is 1 to 3·9 or 4·1. On the first day of fasting stored protein is metabolized; when this becomes exhausted, the organism gradually approaches a condition when it must consume its tissues; after a few days' fasting, the phosphoric acid and nitrogen will be entirely derived from the cleavage of tissue protein, and the ratio of P_2O_5 to N will be as 1 is to 3·9 or 4·1, and is practically stationary at 1 : 4. The great problem of nutrition, therefore, is the protection of tissue proteins from destruction, and it is as important as rebuilding degenerated or effete tissues. Now, it has been observed that other foods than proteins have an influence in protecting the tissues from destruction, and these must be briefly considered.

Carbohydrate as a Protector of Protein.—It has long been observed that, when there is a deficiency of protein in the food, the metabolism of nitrogen will be spared and the tissues protected if the food contains plenty of carbohydrate and fat. This subject was fully investigated by Lusk. When the diet contained an abundance of protein, fat, and carbohydrate, the organism gained a little nitrogen; when the diet contained the same amount of protein, *but no carbohydrate*, the body lost considerable nitrogen. Again, when the food was of the ordinary mixed kind, contained a sufficiency of energy, but was of a low protein character, the excretion of nitrogen was normal. These results led to the conclusion that carbodydrate is a protector of protein.

Fat as a Protector of Protein.—Many investigators have worked at this subject. The metabolism of nitrogenous tissue and elimination of nitrogen is not prevented by the consumption of fat, but the consumption of fat reduces the metabolism of protein so much that one-quarter or one-third as much meat will suffice to maintain the nitrogen in equilibrium as would have to be consumed if only lean meat was used. Wieske concluded that 100 grammes of

[1] *Phiziol. Sbornik*, Charkoff, i. 56-111.

starch diminish protein katabolism 19 to 21 per cent., and 100 grammes of fat 30 to 40 per cent. But when protein and fat only are used (*meat diet*), a very much larger amount must be consumed to maintain the nitrogen in equilibrium than on a mixed diet.

Fat versus Carbohydrate as Protein Protector.—Kayser and Landergren[1] considered they had proved that fat protects protein quite as well as carbohydrates do, both in nitrogen hunger and nitrogen abundance. But Landergren noted in some cases that fat exhibited only half the protective power of carbohydrate, which he explained on the ground that carbohydrates are essential to the body, and when none are supplied glycogen is formed from tissue proteins. Fat cannot serve the place of protein for this purpose. In other words, as soon as the glycogen of the body is used up, fat becomes inferior to carbohydrate as a protector of protein. Atwater[2] found, by observations in the respiration calorimeter, that when the total available energy remains uniform the protection of protein by carbohydrates (largely sugar) is slightly more efficient than an isodynamic quantity of fat, but this may depend on a "personal equation" or individual peculiarity.

Gelatin as Protein Sparer.—Gelatin cannot replace protein as a food; it contains no phosphorus. Animals fed on gelatin, carbohydrate, and fat, die in the same way as those fed on non-nitrogenous diet. Nevertheless, gelatin is more valuable than it has been considered to be. The popular notion is that jelly is strengthening. Physicians, finding this to be erroneous, jumped to the conclusion jelly was no good at all. Both were wrong. Gelatin is apparently all changed into urea, and is a protector of protein, not by lessening the amount of material oxidized in the same way as carbohydrate and fat, but by being directly substituted for the nitrogenous elements of the body. When gelatin is added to the food, the nitrogenous equilibrium is maintained with a smaller amount of protein than when gelatin is withheld, and even the consumption of fat is lessened by gelatin in the food. These facts are intelligible if we consider gelatin to be split into a urea moiety and a fatty moiety, like proteins. If this supposition is correct, gelatin takes the place of stored or circulating protein, but not of tissue proteins, and it does not serve the purpose of tissue formation. The observations of Kolpakcha are a valuable contribution to the subject.[3]

Peptonized Foods and Metabolism.—The question whether prepeptonized foods can take the place of proteins and prevent the destruction of tissue has been investigated. This is of importance in invalid dietetics. Peptonized foods contain a considerable quantity of proteoses, albumoses, and similar bodies, which can be speedily absorbed. What becomes of them? The peptones are broken down into amino-acids and reconstructed into proteins in the alimentary mucous membrane. If commercial peptone is

[1] *Skand. Arch. Physiol.*, 1903, p. 112.
[2] Bulletin 136, p. 197, U.S. Department of Agriculture.
[3] *Phiziol. Sbornik*, Charkoff, i. 56-111.

injected into the blood, it disappears in about three hours by digestion and reconstruction in the interior of leucocytes. It may be assumed, however, that peptonized foods are of value in cases of sickness. Deiters made some experiments with a commercial preparation containing 55 per cent. of albumoses and peptones in the solid dry matter. His observations were made on women suffering from slight illness. He first established a nitrogenous equilibrium on ordinary mixed diet; he then replaced the meat and meat extract by the peptone preparation, and found not only was the nitrogen balance maintained, but that there was a slight gain to the body. Munk made a similar investigation, and obtained equally good results. Politzer[1] also arrived at the conclusion that peptones are of the same nutritive value as proteins of meat, and the albumoses had a somewhat higher value. The slight diarrhœa resulting from their use can be moderated by mixing arrowroot or cornflour in the food.

Meat Extracts and Metabolism.—The nutritive value of any extract of meat is comparatively small. One well-known preparation contains 78 per cent. of solids, including 61 per cent. of xanthin, hypoxanthin, creatin, lactic acid, a trace of peptone, some gelatin and fat, and 17 per cent. of inorganic salts. Meat extracts have a value in promoting the digestion and metabolism of other foods. Some people attribute considerable value to the small amount of albuminous substances, but it all depends on the proportion of proteins. Voit found 10 grammes of extract of meat—a considerable dose—contained only 2 grammes of protein; therefore the proteins in meat extracts should be disregarded. Meat extracts stimulate appetite by their odour and flavour, provoke a secretion of gastric juice, and encourage metabolism in general. Their own nitrogen is converted into urea, and therefore, when no meat is taken, but a large quantity of meat extract, the urinary nitrogen may equal or exceed that produced by ordinary mixed diet. They do not afford any energy to the body, but Foster says,[2] "in some way or another they direct metabolism and the distribution of energy."

Water and Metabolism.—The body consists of 630 parts of water per 1,000. It is of the greatest importance as a component of the tissues, to assist in the exchange of nutritive substances, the discharge of the products of metabolism, the regulation of temperature, and other vital functions. If the supply of water is stopped the body will die, and it may die sooner from deprivation of water than from starvation. A reduction in the amount of water consumed accelerates the decomposition of protein and fat to replace the water essential for the bodily functions.

As the result of forty-five rest experiments, Atwater and Benedict showed that the average income of water is about 4 pints (2,322 grammes), and the excretion 4½ pints (2,684 grammes), so that at

1 Pflüger's *Archiv*, xxxvii. 301.
2 "Textbook of Physiology," ii. 837.

the lowest estimate ½ pint of water is formed in the tissues by the oxidation of hydrogen in the food and tissues, and during ordinary work they found 17 or 18 ounces of water excreted daily in excess of that consumed in food and drink.

The Metabolism of Oxygen and Carbon.—Carbon is essential to produce heat and energy, and the heat is liberated by oxidation. According to Dumas, the amount of carbon excreted by the lungs daily is 8½ ounces, but E. Smith found it varies from 7 to 11 ounces, according to the work done. The amount of oxygen taken in by the lungs and the carbon dioxide excreted have been shown in a previous table in the paragraph on the respiratory quotient. We do not know exactly how the oxidation of carbon and other substances occurs. It may be from the action of nascent oxygen, ozone, hydroxyl, and peroxide of hydrogen. Bunge says ozone does not occur in the body; but nascent oxygen arises in the body during various processes of metabolism, and is a very active oxidizer. Hydroxyl also arises during such processes, and is a very energetic oxidizer. We know, however, that some substances are easily oxidized or auto-oxidizable; others are oxidized with difficulty —bradyoxidizable or dysoxidizable. It is believed that in auto-oxidation a cleavage of the oxygen molecule occurs; that the auto-oxidizable substance seizes one ion and liberates the other. The liberated atom is nascent oxygen, a very energetic ion, which acts upon dys- or brady-oxidizable substances.

According to Traube, the oxidation does not occur in the manner indicated. He considers hydroxyl to be the chief agent. In direct oxidation there is a cleavage of water in H and OH ions. The OH ion combines with an oxidizable substance; and two OH ions unite to form peroxide of hydrogen (H_2O_2), which oxidizes some other body and leaves water. H and OH ions are dangerous to cellular organisms, but Traube and Loew believe the cells are protected from them by cellular enzymes, or *catalases*. Many of these are oxygen-carriers, called *oxidases*, and have a specific action for certain substances, or what Ehrlich calls *monotropism* —that is to say, they oxidize particular bodies, and no others. The existence of cellular enzymes is now considered a settled fact.

The elements which have greatest affinity for oxygen are carbon and hydrogen. These elements predominate in all foods and tissues. The carbohydrates contain enough oxygen to satisfy the hydrogen contained in the molecule, but there is not enough for the carbon also; indeed, two atoms of oxygen are used for every atom of carbon, when the food is completely transformed to carbon dioxide and water. Fat, on the other hand, contains little oxygen. A molecule of stearic acid ($C_{18}H_{36}O_2$) contains only enough oxygen to satisfy four atoms of hydrogen. Proteins present the same state; 100 grammes of protein contains 7 grammes of hydrogen, which requires 56 grammes of oxygen to reduce it to water; but 100 grammes of protein only contains 24 grammes of oxygen, and

enough must be taken from the air to reduce both hydrogen and carbon in the molecule. The ratio of CO_2 to the oxygen inhaled or respiratory quotient therefore varies with the kind of food. With ordinary mixed food the $CO_2 \div O_2 = 0{\cdot}87$; with starch alone the quotient is 1·0; with proteins it is 0·62; and with fat 0·62, or much less than unity. Muscular work causes the respiratory quotient to tend to unity, and it varies from 0·8 to 0·9.

The Mineral Substances in the human body exist therein partly in combination with organic substances, and partly dissolved in the body fluids. The condition of the minerals in any substance is ascertained by dissolving out the inorganic salts, afterwards burning the organic residue, and determining the inorganic substance in the ash. The table on p. 65 gives the most important bodies.

When organic bodies are burnt with access of air, the mineral substances combined with them are set free. The same process occurs when the organized principles of our food become oxidized in the tissues of the body. The liberated salts form new combinations, some probably being organic combinations, but the chief form of such salts is the inorganic condition. The inorganic salts formed in this manner are either eliminated from the body in the urine and other excretions, or they may be retained and recombined with freshly absorbed organic materials from the alimentary canal. The latter view is supported by Forster. If this view is correct, it would appear that a constant supply of salts in the food is unnecessary, or, at any rate, that the absolutely necessary amount of such salts is insignificant. Hammarsten[1] remarks that the amount of mineral substances really needed by man is very small, and that his food usually contains a considerable excess of them; and, accordingly, the quantity of mineral substances daily passing out of the system in the excretions is no guide as to the actual necessity of the organism for them. They are in the food, and must be excreted if they are not wanted. This subject, however, is unsettled, and our knowledge of the requirements of the body for minerals is in an experimental stage. This much is certain: it is impossible for the organism to continue to live when fed on food deprived of its mineral constituents. Forster fed dogs and pigeons on food rendered as poor as possible in mineral substances, and they died earlier than when not fed at all, death being preceded by a disturbance of the functions of various organs, particularly the muscles and nerves, from which he concluded that the full-grown animal required a considerable quantity of inorganic salts. Bunge says the necessity for the constant renewal of the inorganic portion of our frame is not evident. It might be thought *a priori* that, when the body is once built up, it would last indefinitely. But is this a fact?

The body consists very largely of water. Water is essential for the removal of the effete materials arising from metabolism, cell

[1] "Physiol. Chem.," p. 634.

COMPOSITION OF ASH—PERCENTAGES.

	Bone (Heintz).	Muscle (Staffel).	Liver (Oidtmann).	Spleen (Oidtmann).	Brain (Breed).	Blood (Verdell).	Lymph (Dahnhardt).	Milk (Wilderstein).
Sodium chloride ..	—	10·59	—	—	4·74	58·81	74·48	10·73
Potassium chloride	—	—	—	—	—	—	—	26·33
Soda	—	2·35	14·53	44·33	10·69	4·15	10·35	—
Potash	—	34·40	25·23	9·60	34·42	11·97	3·25	21·44
Lime	37·58	1·99	3·61	7·48	·72	1·76	·97	18·78
Magnesia	1·22	1·45	·20	·49	1·23	1·12	·26	·87
Ferric oxide	—	—	2·74	7·28	—	8·37	·05	·10
Chlorine	—	—	2·58	·54	—	—	—	—
Fluorine	1·66	—	—	—	—	—	—	—
Phosphoric acid ..	53·31	48·13	50·18	27·10	50·18	10·23	1·09	19·00
Sulphuric acid ..	—	—	·92	2·54	·92	1·67	—	2·64
Carbonic acid ..	5·47	—	—	—	—	1·19	8·20	—
Silicic acid	—	·81	·27	·17	·27	—	·42	—

growth, and disintegration. But excreted water carries away with it other materials than those arising from organic decomposition. When rain falls from the clouds it consists of pure water; but as it percolates through the earth it takes up various inorganic materials, not only from the soil, but from the apparently eternal rocks. Similarly, in the animal body it dissolves out and carries away some of the inorganic materials, not only from the blood, but from the muscles and other soft tissues, and even from the more solid framework. Salts removed in this way must be replaced. But they are also necessary for other purposes. Forster found that animals fed on proteins freed from salts, with sugar and starch, died sooner than when they were starved. How is this?

Bunge says proteins contain from 0·5 to 1·5 per cent. of sulphur, and during the metabolism of proteins this sulphur is transformed into sulphuric acid. Under ordinary circumstances the sulphuric acid arising in this manner combines with inorganic salts contained in animal or vegetable foods, the acid being thereby neutralized and removed from the body. If there are no salts or bases at hand to neutralize the acid arising in this manner, "it attacks those which form an integral part of the living tissues, and therefore it may figuratively be said to wrench individual bricks out of their places, and thus induce a destruction of the edifice. . . . It may be replied that the organism is able to protect itself against the injurious action of free acids by splitting off ammonia from the nitrogenous organic compounds. But this power is not unlimited, and it is doubtful whether ammonia is invariably present in the particular cells where sulphuric acid is liberated and begins its work of destruction."[1] Lunin supports the view of Bunge. He fed animals on nearly ash-free food, but added sodium carbonate to neutralize acidity, and they were kept alive twice as long as those fed on the same food, but without sodium carbonate. Common salt did not answer the same purpose, nor did sodium carbonate indefinitely prevent death, which is due to the absence of proper minerals from the food. Neither will a haphazard mixture of mineral substances satisfy the system. Animals fed with normal milk will live, but the same animals will die if fed on artificial milk containing exactly the normal proportion of casein, fat and sugar, and the salts of milk, mixed with it. The reason is not clear. It is probable that the salts in normal milk are chemically combined with the organic constituents. The ions of inorganic substances combine with proteins, and it may be assumed that some, at least, of the inorganic constituents of our food are loosely combined with organic constituents, and influence their assimilation and utility.

Among the mineral substances, calcium appears to be essential to the life and functions of protoplasm, but it is unknown in what way it is combined with the essential basis of life. Potassium is another important element, especially of plant life. Without it the assimilation of carbon does not go on. Without a due supply

[1] Bunge's "Physiol. and Pathol. Chem.," pp. 87, 88.

of calcium and potassium, animal bodies waste. Sodium chloride is essential for the due discharge of the metabolic functions, and phosphates appear to be equally necessary.

Chlorides.—The amount of sodium chloride in the adult human body averages 200 grammes. About 15 to 18 grammes are daily excreted in the urine, and smaller quantities in the perspiration and fæces. If potassium chloride is substituted for the sodium salt in the food, various disturbances arise owing to the deficiency of sodium chloride. The latter, therefore, is a most important food. The tissues retain common salt most tenaciously, and when there is none in the food it gradually disappears from the urine. The use which the body makes of it is not clearly understood. The exchange is constantly going on, sodium chloride being taken in and excreted. It facilitates the absorption of protein foods, and increases tissue metabolism. When the supply of common salt is insufficient, not only does the elimination of chlorides in the urine decrease, but there is a diminution of hydrochloric acid in the gastric juice, and consequently a failure of nutrition. There can be no doubt that the hydrochloric acid of gastric juice originates from the chlorides of the blood. Cahn[1] found that, when dogs were deprived of salt, their gastric juice contained pepsin, but no HCl. Again, if there is a lack of sodium chloride as compared with potassium chloride in the food, potassium combinations replace sodium combinations in the body, and new combinations of sodium and potassium are formed and excreted in the urine. Human beings, therefore, who consume a large amount of potatoes and other vegetables rich in potassium salts must of necessity take common salt, not merely as a condiment, but as an essential part of the food.

Vegetable foods contain three or four times as much potassium as animal foods. This led Bunge to the conclusion that it is the abundance of potassium in vegetable foods which causes the necessity for the consumption of sodium chloride with them. He says:[2] "If a salt of potassium, such as the carbonate, meets with common salt or sodium chloride in solution, a partial exchange takes place, potassium chloride and sodium carbonate being formed. Sodium chloride is the chief inorganic salt of the blood-plasma. When, therefore, salts of potassium absorbed with the food reach the blood, an exchange takes place, chloride of potassium being formed and a sodium salt of the acid. Instead, therefore, of sodium chloride, the blood now contains another sodium salt which is not a normal constituent of the blood or in its normal proportion. This new sodium salt is ejected by the kidneys together with the chloride of potassium, and the blood is thereby impoverished of sodium and chlorine. This loss can only be made good from without, but it explains the craving for salt which affects animals living upon a diet rich in potassium. A man living chiefly on potatoes takes in the course of the day 40 grammes of potassium. All the important

[1] *Zeit. f. Physiol. Chem.*, x.

[2] "Phys. and Path. Chem.," p. 91.

vegetable foods are rich in potassium, which explains the fact that people who live largely on a vegetable diet use more salt than those who eat a good deal of animal food. Bunge gives the following instructive tables:

THE POTASSIUM AND SODIUM IN 1,000 PARTS OF DRIED SUBSTANCE.

	K_2O.	Na_2O.
	Grammes.	Grammes.
Rice	1·0	·03
Blood of ox	2·0	19·00
Oats, wheat, rye, and barley ..	5 to 6	·1 to ·4
Dog's milk	5 to 6	2 to 3
Human milk	5 to 6	1 to 2
Apples	11·0	1·0
Peas	12·0	·2
Milk of herbivora	9 to 17	1 to 10
Hay	6 to 18	·3 to 1·5
Beef	19·0	3·0
Beans	21·0	·1
Strawberries	22·0	·2
Clover	23·0	·1
Potatoes	20 to 28	·3 to ·6

AMOUNT OF POTASSIUM IN SUBSTANCE FOR EVERY GRAMME OF SODIUM.

Blood	·07 gramme.
Egg-albumin	·7 ,,
Yolk of egg	1·0 ,,
Milk of carnivora	·8 to 1·6 grammes.
,, of herbivora	·8 to 6·0 ,,
,, of women	1·0 to 4·0 ,,
Beef	4·0 grammes.
Wheat	12 to 23 grammes.
Barley	14 to 21 ,,
Oats	15 to 21 ,,
Rice	24 grammes.
Potatoes	31 to 42 grammes.
Strawberries	71 grammes.
Apples	100 ,,
Beans	110 ,,

The use of common salt, therefore, enables mankind to consume more freely the vegetable products of the earth. The foregoing tables show that the proportion of potassium is highest in wheat, barley, rice, potatoes, peas, and beans. These are the staple foods of the poorer classes, and therefore salt is an absolute necessity to them. On the other hand, a very large number of people consume more salt than they require. Salt is not only a food, it is a condiment, and as such is liable to abuse. If the proportion of sodium and potassium in milk is taken as a standard, when the diet consists of cereals and legumes, about 2 to 4 grammes of salt a day would be sufficient to maintain the balance, and when the diet

consists of rice a few decigrammes would be enough and very little is needed with an ordinary mixed diet, whereas most people take 20 to 30 grammes daily in one way or another. The kidneys have to excrete the excess of salt, and it may reasonably be asked: Do we not impose too great a task upon them, and is it not attended with danger?

When the diet consists of bread and meat *without salt*, not more than 6 or 8 grammes of alkaline salts are excreted in twenty-four hours, but with a diet of potatoes *and salt* more than 100 grammes of alkaline salts pass through the kidneys in a day. When the diet consists of rice, only about 2 grammes of alkaline salts are excreted a day. In health the kidneys appear to eliminate chlorides without difficulty. The urine is richest in chlorides after a meal, and poorest at night-time. Drinking large quantities of water increases the excretion. It is diminished in most febrile diseases, especially in pneumonia, pleurisy, and enteric fever, and increased in diabetes, polyuria, and some forms of Bright's disease, where a large amount of water is excreted. In nephritis the kidneys do not excrete salt so easily as in health, but this is not constant, the power of excreting water, salt, and urea, varying from time to time. The deficiency is most marked in acute nephritis and chronic parenchymatous nephritis, while in granular kidney the excretion may be normal or increased, except during an exacerbation. The failure to eliminate salts from the body leads to a retention of chlorides. In the retention of chlorides it has been observed that the basic ion *sodium* is retained in many cases, while the potassium ion passes out. The retention of the sodium ion leads to the retention of water also, the retention of salt in the tissues causing them to hold more water by increasing the osmotic attraction. In pathological conditions the retention of sodium is associated with œdema and ascites; whether as cause or effect is not clear. Bainbridge considers it to be the primary condition. Whether it is so or not, it is absolutely certain that restriction of the consumption of common salt is beneficial in such cases. Widal and Javal observed a diminution of the œdema in chronic nephritis when salt was withdrawn from the food, and an increase of œdema when the salt was increased. The œdema diminishes because salt continues to pass out of the system and carry water with it; it increases when salt is retained, because of its attraction for water. A salt-free diet (*q.v.*) is therefore more beneficial in œdema, ascites, anasarca, and serous effusions, than restriction of the consumption of water.

The Alkaline Carbonates and Bases.—The chemical processes of the body are dependent on the existence of a certain reaction in the fluids, and this reaction, which is habitually alkaline towards litmus and neutral towards phenolphthaleïn, is chiefly due to the presence of alkaline carbonates and carbon dioxide. The alkaline carbonates are of importance not only as a solvent for some of the proteins and as a constituent of the secretions, but also as a means

for the transportation of carbon dioxide in the blood. It is therefore easy to understand that a decrease in the quantity of alkali carbonates below a certain point must endanger life. Such a decrease may arise from a lack of bases in the food, which accelerates death, as already shown, by the production of acids from the destruction of proteins. Potassium is necessary for the development of cells, especially those of the blood and muscles. Sodium is required to make the secretions of a proper composition, and sodium carbonate is necessary to carry carbon dioxide from the tissues to the lungs. It has been shown that when young animals are deprived of potash salts they do not develop muscle. Scurvy in adult animals has been attributed to the absence of potassium salts, and this idea receives support from the beneficial effects of fresh vegetables and fruit upon the course of that disease.

It may be that potassium is only an acid-carrier in the adult organism; at any rate, we know that the organic acids combined with it undergo oxidation, and acid salts of potassium become transformed into alkaline carbonates, and thereby render the blood and secretions alkaline. Potassium salts occur chiefly in vegetable foods, sodium salts in animal foods. Animal foods contain enough sodium, but vegetables contain, probably, an excess of potassium, and it is a custom to eat salt with them. Bunge says in effect that Nature demands the consumption of salt with vegetables because of the antagonism which exists between potassium and sodium; that the great amount of potassium in such foods would lead to the excretion of all the sodium from the body if it were not constantly replaced. Forster and other physiologists do not accept this statement, but they do not give a better explanation for the craving for salt, which appears to be stronger in those who consume chiefly a vegetarian diet than in those whose food is largely animal diet. Perhaps the true explanation depends on the amount and kind of salines in the food. Roberts arranged the following foods in the order of their salines: Rice contains 0·39, wheat-flour 0·51, meat 0·52, milk 0·56, fish 7·0, green vegetables 11·0, salads 12·0, and oysters 23·0, per cent. The salines of the blood and urine are deficient in all cases of gravel, and this deficiency is one of the causes of its production. Calculus rarely affects the children of well-to-do people, but it is common amongst the poor. The chief reason why calculus affects the poor, according to Roberts, is because bread, their chief food, is deficient in salines. In potatoes the chief salines are salts of potash, and so are those of cabbage and other green vegetables and fruit.

Lime in the Food.—Calcium is one of the most important constituents of the food. As far back as 1842 Chossat found that pigeons were adversely affected when fed with food deficient in lime. The birds suffered from diarrhœa, thirst, their feathers became ruffled, general health suffered, and they died after eight or nine months of such dietary, when it was observed that their bones were unusually soft. Voit, Seeman, and Baginsky, observed

that animals fed with a diet of flesh and *distilled* water increased in weight and appeared to be normal for a long time; but eventually they became weak, and their bones suffered various changes, owing to the gradual disappearance of lime from their tissues and bones. Young lions cannot be reared on flesh unless bonemeal is added to it. The addition of phosphate of lime to meat diet improved the general condition of rats. Calcium therefore is an essential substance for the formation of the bones and various tissues. In the human organism three calcium periods may be recognized: (1) *The period of growth,* when the organism requires all the available calcium for the growth and formation of the bony skeleton and other tissues. (2) *The period of reproduction:* Calcium is required in reproductive processes for the growth of the fœtus, the formation of milk, and other secretions. (3) *The period of old age:* Calcium is no longer required for the formation of tissues in the organism nor for reproduction. The salts tend to accumulate in the tissues, especially in the bloodvessels, causing atheroma, atrophy of tissues, and a gradual degeneration of the organism.

Calcium phosphate forms about 70 per cent. of the total minerals in the body. This is because of its great preponderance in the bones. Calcium carbonate, sulphate, and fluoride, also occur in the bones and teeth, and most tissues contain small quantities of calcium carbonate and phosphate.

During the period of growth a considerable amount of inorganic salts is necessary for constructive purposes, and is derived from the food. The inorganic constituents in the body of a sucking animal correspond very closely with the inorganic constituents in the milk of its mother, and the tissues of the sucking animal are built up in accordance with the composition of the milk. The close correspondence between the inorganic materials in the milk and ash of the young animal's body is the more remarkable inasmuch as the ash of the blood is completely different from the ash of the milk and the body of the young animal. This is clearly shown in the following table:[1]

THE ASH OF BODY, MILK, AND BLOOD, COMPARED—PERCENTAGES.

	Sucking Young of—			Dog's Milk.	Dog's Blood.	Dog's Serum.
	Rabbit.	Cat.	Dog.			
K_2O	10·80	10·10	8·50	10·70	3·1	2·40
Na_2O	6·00	8·30	8·20	6·10	45·6	52·10
CaO	35·00	34·10	35·80	34·40	·9	2·10
MgO	2·20	1·50	1·60	1·50	·4	·50
Fe_2O_3	·23	·24	·34	·14	9·4	·12
P_2O_5	41·90	40·20	39·80	37·50	13·3	5·90
Cl	4·90	7·10	7·30	12·40	35·6	47·60

[1] Bunge's "Physiol. and Pathol. Chem.," p. 82.

The animals when killed were only four days old. It could not be said that the tissues were built up by the milk they had consumed, but that they were born with an ash corresponding pretty closely with that of the milk. Bunge says the young of all mammalia are born with an ash corresponding in composition with that of the milk. It remains, therefore, to be seen how far these inorganic salts can be obtained in foods other than milk, and whether the young animal will continue to obtain the salts necessary for its growth when deprived of its natural milk and fed with other substances. A comparison of the ash of various substances will throw light on the subject. I am again indebted to Bunge[1] for the following table:

Composition of the Ash of Foods—Percentages.

	K_2O.	Na_2O.	CaO.	MgO.	Fe_2O_3.	P_2O_5.	Cl.
Beef	1·66	·32	·029	·152	·020	1·83	·28
Wheat	·62	·06	·065	·240	·026	·94	?
Potato	2·28	·11	·100	·190	·042	·64	·13
Egg-albumin	1·44	1·45	·130	1·130	·026	·20	1·32
Peas	1·13	·03	·137	·220	·024	·99	?
Human milk	·58	·17	·243	·050	·003	·35	·32
Yolk of egg	·27	·17	·380	·060	·040	1·90	·39
Cow's milk	1·67	1·05	1·510	·200	·003	1·86	1·60

Lime is the chief inorganic material required by the growing body. As foods contain sufficient of the other salts, calcium is practically the only element we have to consider. Cereals and flesh do not contain enough lime, and a young child would not obtain sufficient from them to satisfy the demands of the organism for bone formation. Leguminous foods contain more lime, but, unfortunately, they are in other respects unsuitable for an infant's food. Milk and yolk of egg contain enough lime, and the latter can be combined with the former in various mixtures (see Infant-Feeding).

Spring water contains lime, and lime-water is a saturated solution of lime; but their value is disputable, and our knowledge of the action of inorganic lime in the body is unsettled. Bunge says inorganic lime is not assimilated. The amount of lime in lime-water is not so great as in milk. One pint of cow's milk contains 1·7 grammes CaO, but 1 pint of lime-water contains only 1·3 grammes of CaO. In milk the lime is organically combined with the casein, and in other foodstuffs, also, it is in organic combination. It is therefore more rational to give such foods than lime-water. It has been conclusively proved that a deficiency of lime in the food leads to defective formation of bone and the production of rickets. When young animals are fed with artificial food deficient in lime salts, the bones become abnormally pliable

[1] "Physiol. and Pathol. Chem.," p. 84.

and brittle; indeed, the characteristic features of true rickets are produced. But our knowledge of the pathology of rickets is still incomplete. Some children become rickety whose food constantly contains enough lime, whence it may be concluded that deficiency of calcium is not the sole cause of rickets, but that there is a defective calcium metabolism, an inadequate absorption of the ingested lime, combined with abnormal processes in the bone-forming elements. It is estimated that a child requires $\frac{1}{3}$ gramme of calcium daily, and it is probable that to insure absorption it must be organically united to the proteins of the food; for, in spite of the addition of lime-water to diluted cow's milk, rickets may continue to prevail. Cow's milk is richer in lime and other inorganic salts than human milk. The greater rapidity of growth in the calf as compared with the human infant is correlated with this fact. The absence of a sufficient quantity of fat in the food, and also an excessive quantity of fat, tends to deprive the growing body of its normal supply of calcium and magnesium.

Calcium in Adult Life.—Calcium is the most abundant metal in the body. Its phosphate is the chief constituent of bone; its protein combinations are essential to the nucleated cells which are most active in nutrition; and its soluble salts have an influence upon the activity of the muscles and the properties of the body fluids. According to Bunge, inorganic salts of lime are useless to the body, but Lusk found that both organic and inorganic lime were absorbed. Forster found that 60 per cent. of the lime in food is absorbed, and that the greater portion of the metabolized lime is eliminated by the cells of the intestinal mucous membrane. The calcium requirement of the adult body appears to be about 0·75 gramme of CaO per day. According to Wendt and Renvall, the intestinal mucous membrane eliminates from 60 to 90 per cent., and the kidneys from 10 to 40 per cent. Adults do not require so much calcium in proportion to their weight as growing children, especially as their bones have ceased to grow. It is very probable that the ordinary diet of adult life contains enough and to spare. But recent investigations show that it is not safe to *assume* that a diet containing sufficient protein and energy *necessarily* furnishes enough lime. This is a point which can only be settled by metabolism experiments in which a balance is made between the intake and the output. The most recent investigation is that made by Sherman, Mettler, and Sinclair.[1] It is impossible to give an account of this work in a short space, but the table by them on p. 74 shows the average amount of calcium, magnesium, phosphorus, and iron, consumed daily on various dietaries.

The investigators make the following observations: Dietaries rich in protein have a fairly high proportion of phosphoric acid, but the parallel is not so close in the case of protein and iron, and there are greater discrepancies with calcium and magnesium. It can, therefore, no longer be said that the amount of protein in the

[1] Bulletin 227, Experimental Station, U.S. Department of Agriculture.

THE MINERALS IN TYPICAL DIETARIES: DAILY QUANTITIES PER MAN.

Subjects of the Study.	Fuel Value.	Protein.	Iron (Fe).	Phosphoric Acid.	Calcium Oxide.	Magnesium Oxide.
	Calories.	Grammes.	Grammes.	Grammes.	Grammes.	Grammes.
Maine lumbermen	6,780	179	·035	5·88	1·27	1·21
School superintendent's family, Chicago	3,260	123	·021	3·97	1·09	·55
Students' Club, University of Tennessee	3,595	123	·019	4·05	1·22	·63
Decorator's family, Pittsburg	3,305	112	·019	3·44	·90	·48
Farmer's family, Connecticut	3,545	108	·021	3·53	1·15	·55
Teacher's family, Indiana	2,780	106	·016	3·64	1·42	·44
,, ,, New York City	3,180	102	·017	3·92	1·69	·54
Mechanic's family, Tennessee	4,060	97	·017	3·58	·90	·72
Farmer's and mechanic's family, Tennessee.. ..	2,820	95	·019	3·56	·83	·59
Glass-blower's family, Pittsburg	3,085	94	·016	2·73	·49	·36
Lawyer's family, Pittsburg	3,280	91	·015	2·82	·83	·40
Women Students' Club, Ohio	3,330	85	·015	2·88	·97	·67
Lawyer's family, New York City	2,325	84	·014	2·41	·47	·30
Labourer's family, Pittsburg	2,525	83	·013	2·40	·50	·34
Negro family, Alabama	4,955	80	·012	3·25	·21	·74
Labourer's family, Pittsburg	2,440	77	·012	1·52	·40	·19
Labourer's family, New York City	2,430	71	·012	2·27	·50	·29
Farm Students' Club, Tennessee	3,560	66	·011	2·08	·46	·34
Sewing-woman's family, New York City	1,500	54	·009	1·84	·68	·23
Very poor negro family, Alabama	2,240	44	·007	2·05	·08	·52

dietary is a sufficient measure of its richness in building material. Apart from the proportion of nitrogen, especial attention should be given to the amount of calcium, phosphorus, and iron, in the food. Metabolism experiments show that a healthy man requires 0·75 gramme of calcium per day, but many of the dietaries in the above table contain less than that amount. Gautier and Albu assert that the food should contain at least 1·0 to 1·5 grammes CaO per diem. If this is true, the majority of the above diets are defective in this respect, and would be improved by including a greater quantity of milk, cheese, junket, koumiss, buttermilk, etc., or peas and beans, in the dietary.

Adults, however, do not require so much calcium in proportion to their weight as infants. The ordinary foods probably contain enough for most persons who have attained middle age. In some diseases the metabolism of calcium is defective—*e.g.*, senile osteoporosis, formation of osteophytes, ossification of muscles, etc. In the latter calcium is retained in too great a proportion; in the former it appears that calcium is not absorbed in sufficient amount. Von Limbeck[1] investigated two cases of senile osteoporosis. The subjects were old women, in whom the metabolism of calcium oxide was defective, or the food did not contain enough to supply the needs of the organism. At any rate, the subjects lost considerable calcium oxide each day. It was excreted almost entirely by the intestinal mucous membrane, and the investigator remarked that such a loss could not continue very long without producing a fatal result.

METABOLISM OF CaO IN OSTEOPOROSIS.

1. Woman, aged 78: In food, CaO, ·6; in urine, ·1; in fæces, 1·7; loss, 1·2 grammes.
2. Woman, aged 81: In food, CaO, ·6; in urine, ·03; in fæces, 1·4; loss, ·8 gramme.

Among the diseases of late middle life and old age, calcareous degenerations rank as a serious trouble. What leads to the deposition of calcium in these cases is not clearly known. It may be that a similar defective metabolism to that which leads to rickets is also the cause of the accumulation of lime in unwonted situations, especially the intima of the bloodvessels, at this late period of life. Other ailments ascribed to an excess of lime in the food are calculus and constipation. Calcium lessens the muscular activity of the alimentary canal. One of the chief sources of lime is the *hard water* which we drink. Unboiled water contains more lime than boiled water. But milk contains more calcium than hard water does. Eggs come next to milk in the proportion of lime. A still smaller, but important, quantity also occurs in the cereals—especially rice—spinach, asparagus, and radishes. According to Rumpf,[2] bread, meat, fish, potatoes, apples and other fruit, are poor in calcium, and should form the chief food of atheromatous subjects.

[1] *Prager Med. Woch.*, 1894, p. 381.

[2] *Berl. Klin. Woch.*, 1897, xiii.

On the other hand, Katz found that the flesh of young animals—*e.g.*, veal—is rich in lime, and therefore ought to be avoided by them.

Oxalate of Lime.—Calcium occurs in some foods in combination with oxalic acid. The consumption of foods containing this salt of lime is said to lead to the formation of oxalate of lime calculus, or gravel. Whether the formation of this stone is due to an excess of the lime salt in the food or to retention owing to some defect of metabolism is not clearly known. Nephritic attacks have been known to occur after the consumption of rhubarb, especially when hard water was drunk. The amount of oxalic acid excreted daily by men is 0·1 gramme, according to Schultzen.[1] It never occurs in a free state in the urine, but always as calcium oxalate, which under ordinary circumstances is kept in solution by acid phosphate of sodium. When present in excess in the urine, it is precipitated in crystals, and gives rise to symptoms of oxaluria: dyspepsia, nervous exhaustion, mental distress, or spermatorrhœa; and may be due to excess of saccharine foods, alcoholic liquors, mental trouble or overwork, and is aggravated by the consumption of foods containing a large percentage of oxalate of lime. According to Esbach, the amount of oxalic acid in foods is as follows:

Oxalic Acid in Foods per 1,000.

Cauliflower	·003	Chicory	·103
Parsley	·006	Coffee	·127
Strawberries	·012	Breadcrumb	·120
Lettuce	·016	Crust of bread	·130
Endive	·017	Prunes	·120
Cherries	·025	Currants	·130
Brussels sprouts	·020	Beans	·158
Carrot	·027	Buckwheat	·171
Orange and lemon	·030	French beans	·06-·212
Maizemeal	·033	Haricot beans	·312
Barleymeal	·039	Dried figs	·270
Potatoes	·046	Beetroot	·390
Bread (whole loaf)	·047	Black tea	2·060
Tomatoes	·002-·052	Rhubarb	2·466
Raspberries	·062	Spinach	1·91-3·270
Gooseberries	·070	Sorrel	2·74-3·630
Plums	·070	Pepper	3·250
Salsify	·070	Cocoa powder	3·52-4·500

The foods which contain most oxalic acid should certainly be prohibited in cases of oxaluria, oxalate of lime gravel, and in other conditions when calcium oxalate crystals occur in the urine. These include tea, coffee, cocoa, spinach, rhubarb, sorrel, pepper, beetroot, and beans. Only a small quantity of raspberries, gooseberries, plums, currants, prunes, grapes, and figs, should be allowed. The excretion of oxalic acid or oxalate of lime will be encouraged by a dietary which is deficient in these elements—viz., animal foods, bread, potatoes, cabbage, Brussels sprouts, cauliflower,

[1] *Arch. f. Anat. u. Physiol.*, 1868, 719.

carrots, lettuce, endive, strawberries, cherries, oranges. Tomatoes are stated above to contain 0·002 to 0·052 per cent. of *oxalic acid*, but, according to more recent authorities, the chief organic acid in tomatoes is citric acid.

Magnesium is of considerably less importance than calcium to the body. The total amount is estimated to be only one-twentieth the amount of lime. Very little is absorbed from the food, about one-third being excreted in the urine and two-thirds in the fæces. Magnesium salts are more soluble in the fluids of the body than calcium salts. Whereas 99·5 per cent. of the total lime in the body is deposited in the bones, only 71 per cent. of magnesium is in the bones. The muscles contain more magnesia than lime, but the blood contains more lime than magnesia. It is absorbed from the intestinal canal both in the organic and the inorganic condition. When animals are fed on a diet containing little calcium, but an abundance of magnesium, the bones may be brought to contain double the normal quantity of magnesium; but the skeletal development lags, whence it is considered proved that magnesium cannot be a substitute for calcium. The magnesium salts, being more soluble, are excreted in greater proportion than calcium by the kidneys; in fact, the greater part of the absorbed magnesium leaves the body in the urine, while the unabsorbed magnesium salts form insoluble soaps, and are excreted in fæces. Magnesium phosphate occurs in the tissues along with calcium phosphates, and appears in the urine in the form of triple phosphate (ammonio-magnesium phosphate). Foods in general contain about the same amount of magnesium as of calcium, but meats in general contain 0·076 gramme CaO and 0·19 gramme MgO per 100 grammes of protein; fish contains 0·18 gramme CaO and 0·23 gramme MgO per 100 grammes protein; milk and its products contain more lime than magnesia, while in bread they are nearly equal.

Phosphorus is essential for all cells. Wherever new cells are formed, this element is necessary as a building material. It is, therefore, a most important constituent of the food of growing children, and any deficiency must be followed by impairment of the growth. It is especially needed for the neurons or cells of the central nervous system and for the bones. But there is a difference in the condition of the phosphorus in these tissues. The phosphorus of bones and other hard tissues exists in the form of earthy phosphates and alkaline earths, which enter the system as the inorganic phosphates of the food. The phosphorus in the important or more vital cellular elements is organized, and consists of nuclein and various phosphorized fats or lipoids, such as lecithin, cerebrin, and cholesterin.

Rohmann inquired:[1] What influence have the inorganic phosphates on the construction of phosphorized proteins in the body? He fed animals with earthy phosphates and diets consisting of (1) phosphorized proteins (casein and vitellin), (2) non-phosphorized

[1] Pflüger's *Archiv*, lxvii.

protein (edestin). With the former diet there was a retention of nitrogen and phosphorus in the body; with the latter none occurred. He concluded from these observations that the body does not appear to have the power of building up the phosphorized proteins of the cells from non-phosphorized proteins and inorganic phosphates. On the other hand, the phosphorized proteins appear to be built up from lecithin and non-phosphorized protein. It is therefore to the phosphorized organic constituents of the food we must look for our supply of phosphorus—viz., nucleo-proteins, phospho-proteins, nuclein, lecithin, cholesterin, phospho-carnic acid, and glycero-phosphoric acid, found in the cellular elements, particularly in egg-yolk, sweetbread, fish-roe, the germ of cereals and legumes, and in casein. The amount of phosphoric acid in various foods was stated by Girard[1] to be as follows:

P_2O_5 IN FRESH FOODS.

Animal Foods.	Per Cent.	Vegetable Foods.	Per Cent.
Pork	·160	Carrot	·036
Milk	·220	Turnip	·058
Beef	·285	Cabbage	·089
Eggs	·337	Potato	·140
White cheese	·374	Chestnuts	·200
Mutton	·425	Barleymeal	·230
Gruyère cheese	1·350	Haricot beans	·924

Bunge[2] found the amount of P_2O_5 in 100 grammes of *dried* substance was as follows: Yolk of egg 1·90, cow's milk 1·86, beef 1·83, peas 0·99, wheat 0·94, potato 0·64, white of egg 0·20, gramme. Voit estimated that a human body weighing 70 kilos (154 pounds) would contain — in the bones 1,400 grammes phosphorus, in the muscles 130 grammes, in the nervous system 12 grammes. An attempt to find the phosphorus requirement of the body is fraught with difficulties analogous to those surrounding the protein requirement. The data available for establishing a phosphorus standard are fewer than those existing on the subject of nitrogen. But experiments show that the requirement of phosphorus varies between 0·9 and 1·5 grammes per diem, the difference being due in part to the condition of the phosphorus in the diet. The experiments of Sherman and Sinclair are valuable, and their report states that at present it can only be said that the data now available indicate that a healthy man, by accustoming himself to a low phosphorus intake, or by the selection of food containing phosphorus almost entirely in organic combination, may maintain equilibrium on a diet furnishing about 0·9 gramme of phosphorus or 2 grammes P_2O_5; but that maintenance of equilibrium at the normal level of a full diet, so as to insure the carrying of a full

[1] *Compt. Rend.*, 1896, cxxii. 1387. [2] "Physiol. and Pathol. Chem.," p. 84.

normal store of phosphorus compounds in the body, appears to call for the intake of about 1·5 grammes of phosphorus or 3·5 grammes of P_2O_5 daily.[1] But further experiments are necessary, regard being had to the sources of the phosphorus, which may be grouped as follows: (1) Inorganic phosphates; (2) simple organic combinations of phosphoric acid or phosphates—*e.g.*, phytin or plant-vitellin and phyto-albumose; (3) phosphorized fats—*e.g.*, lecithin, cholesterin, cerebrin; (4) phosphorized proteins—*e.g.*, nucleo-proteins, phospho-proteins. Kolpakcha undertook experiments to discover the influence of food upon protein metabolism, and found that the amount of phosphorus excreted in the urine and fæces was directly proportional to the phosphorus content of the food. These experiments have been referred to previously (p. 60). The amount of phosphoric acid in the food and the excretions, together with the gain or loss to the body, was as follows:

PHOSPHORUS METABOLISM: P_2O_5, GRAMMES.

Arrangement.	Days.	Food.	Urine.	Fæces.	Gain or Loss.
1. Fasting	6	—	1·1	—	−1·1
Meat, 600 grammes	4	2·9	2·8	·2	− ·9
,, 1,200 ,, ...	4	5·7	4·7	·4	− ·4
,, 1,800 ,, ...	2	8·6	6·9	·9	+ ·8
White of egg, 1,000 grammes; lard, 30 grammes	5	·4	·5	—	− ·1
White of egg, 1,500 grammes, lard, 30 grammes	2	·6	·6	—	—
Gelatin, 112 grammes; lard, 50 grammes	3	—	·8	·1	− ·9
Gelatin, 150 grammes; lard, 50 grammes	2	—	·5	·1	− ·6
Gelatin, 180 grammes; lard, 50 grammes	3	—	·5	·1	− ·6
2. Fasting	1	—	3·2	—	−3·2
Liver, 800 grammes	3	7·4	6·7	·6	+ ·2
Lungs, 800 grammes	3	3·2	2·8	·4	—
Yolk of egg, 500 grammes ..	4	6·9	5·1	1·1	+ ·7
White of egg, 600 grammes; yolk, 250 grammes	4	3·8	3·0	·8	—

The phosphorus of the tissues is chiefly in the nucleins and nucleo-proteins of the cells, which are the most active in metabolism; whereas the inorganic materials of the bones is commonly assumed to be inactive. There has therefore been a general tendency to assume that the output of phosphorus may be regarded as a measure of the nucleo-protein metabolism, just as the output of nitrogen is considered a measure of protein metabolism in general. Thus, an intimate connection between the phosphorus eliminated and the katabolism of nucleins is assumed by Dunlop, Paton, and their

[1] Bulletin 227, Experimental Station, U.S. Department of Agriculture, p. 39.

collaborators,[1] when interpreting the results obtained by an investigation of the effects of muscular exertion. The investigation was made upon persons who rode a bicycle daily as long as possible without serious discomfort, and who were taking a diet of known composition and amount during a period of seven days. In each case the exertion caused an increased elimination of nitrogen and sulphur, but only when the subject was in poor training was there a corresponding increase in the elimination of phosphates and uric acid. They therefore concluded that when the subject was in good training the muscular exertion only caused the breaking down of simple proteins; when the subject was in poor training there was a breaking down, not only of the simple proteins, but of the nucleo-proteins also. On the other hand, it was shown by Voit that the material katabolized during fasting comes largely from the bones; while Jordan and Patten,[2] after making extended observations on animals, concluded that the phosphorus metabolism consists largely in the formation of inorganic phosphates from comparatively simple organic compounds such as phytin. Therefore, whether the amount of phosphorus eliminated can or cannot be taken as a measure of the metabolism of nucleo-protein, it is certain that the output of phosphorus and the output of nitrogen do not run on parallel lines, and cannot be taken as a measure of the same set of changes.

It is essential for the growth of new tissues that phosphorus should be stored in the body as well as nitrogen. Whenever there is a storage of nitrogen, a corresponding storage of phosphorus occurs. The importance of phosphorus as a building material was shown by Bunge when he discovered that the proportion of phosphorus, calcium, and protein, in the milk of animals is directly proportionate to the rapidity of growth.

	Time required to double the Weight of a New-born Animal: Days.	Milk of Mother contains—			
		Protein.	Ash.	Lime.	P_2O_5.
		Per Cent.	Per Cent.	Per 1,000.	Per 1,000.
Man	180	1·6	·2	·328	·473
Horse	60	2·0	·4	1·240	1·310
Cow	47	3·5	·7	1·600	1·970
Goat	19	4·3	·8	2·100	3·220
Sheep	10	6·5	·9	2·720	4·120
Dog	8	7·1	1·3	4·530	4·930

Iron is essential to the human body. It is taken into the body in the food, excreted by the liver, and leaves the body in the fæces. Owing to the fact of iron entering and leaving the body by the alimentary tract, it appears impossible to determine the amount required daily. Stockman, however, estimates that the

[1] *Journal of Physiology*, 1897-98, p. 68.
[2] *American Journal of Physiology*, 1906, p. 268.

typical food of an adult contains 10 milligrammes of iron daily, and that it is sufficient for the needs of the body. The blood of an adult contains 3 grammes of iron; the liver, spleen, skin, and hair, contain smaller amounts; it is excreted from the body in the bile and the fæces. The hæmoglobin of the blood contains 0·04 per cent. of iron. The spleen contains a large proportion of iron. According to Hasse, the spleen pulp of old horses contains 5 per cent. Oidlmann found that the ash of the spleen contains from 7 to 16 per cent. of iron. The iron existing in the blood is in the form of hæmoglobin. That in the spleen is likewise hæmoglobin. The splenic cells are believed to have the function of liberating hæmoglobin from effete blood-cells; the hæmoglobin passes from the spleen to the liver, where it undergoes various changes. The amount of iron in liver which has been washed free from blood varies within very wide limits. Bemmelin gives it as averaging 0·1 per cent.; Hunter gives it as only 0·087 per cent. It is reduced in leukæmia to 0·01 per cent., but increased in pernicious anæmia, because the normal destruction of hæmoglobin by the liver is then much exaggerated. Iron exists in the cells of the liver as a compound or compounds of iron with nuclein and protein; two of these compounds have been named *hepatin* and *ferratin*; and the iron is either the ferric or ferrous oxide. The proportion of iron in the liver of the new-born animal is greater than that in the adult. Bunge believes that the liver acts as a storehouse of iron subsequently used in the form of red blood-corpuscles. Delépine agrees with this, but goes farther; he considers the liver is not only a storehouse of the nucleo-protein compounds containing iron, but that the liver cells elaborate these compounds into *new* hæmoglobin for young red blood-corpuscles. This is described by him as the *ferrogenic function* of the liver, which persists throughout life. *The liver also excretes iron.* The bile pigment is derived from hæmoglobin, and is free from iron. This pigment is split off from the hæmoglobin, the iron-bearing nucleo-proteins being stored in the cells of the liver; but some of the iron is excreted in the bile in the form of a phosphate which forms from 0·004 to 0·010 per cent. of that fluid.

The iron of the body is derived from the foods; but it is probably not derived from the oxide and other inorganic salts of iron. Considerable doubt has arisen as to whether inorganic iron, given as a drug for the cure of anæmia and chlorosis, is absorbed. Von Noorden, Stockman, and others, assert that inorganic iron is absorbed, and is very efficient in the treatment of anæmia and chlorosis. Hamburger and Mörner consider that little or none of the inorganic preparations of iron is absorbed from the alimentary canal. The total amount of iron in the blood is only 3 grammes, but many times that amount is taken during a course of treatment for anæmia. Bunge explains the usefulness of iron in the treatment of anæmia and chlorosis in the following way: Chlorosis is attended by considerable fermentation in the alimentary canal, whereby much sulphuretted hydrogen is evolved; and this gas,

he says, destroys the organic compounds of iron in the food, which are normally utilized to manufacture hæmoglobin. If, however, an excess of inorganic iron is likewise present, some or most of the sulphuretted hydrogen evolved will combine with such iron to form a sulphide, and in that manner it protects the organic iron combinations from destruction by H_2S.

If the blood is deficient in iron, it would scarcely be possible to make good that deficiency by inorganic salts in the food. Very few foods contain much inorganic iron, although Stockman and Von Noorden have expressed the belief that the inorganic iron contained in the food is absorbed and utilized in the production of hæmoglobin. Moreover, if the food is deficient in iron, it would *a priori* lead to anæmia; and this idea receives support from various observations—*e.g.*, the blood of dogs fed with bread contained less iron than the blood of the same animals fed with meat. If young animals receive only the same proportion of iron per kilo of body-weight as is necessary for adults, they become anæmic. When fed with food devoid of iron, animals lose 40 per cent. of their iron in three weeks; when fed with food containing it, iron is absorbed from the duodenum and jejunum.

The chief source of iron in the blood and tissues is undoubtedly the organic combinations, such as the *hæmatogens*, or compounds of iron and nucleo-protein or nuclein, in the cells of animals and vegetables. It is not known exactly what proportion the organic bears to the inorganic iron in our foods; but it is undoubtedly highest in blood, liver, spleen, muscle, and yolk of egg; it is also high in oatmeal, lentils, spinach, and apples. Bunge puts foods in the following order, spinach containing most and wheat least iron: Spinach, yolk of egg, beef, apples, lentils, strawberries, white beans, peas, potatoes, wheat. Boussingault[1] gives the following table:

Iron in Fresh Substance: Grammes per 1,000.

Blood of pig	·634	Cabbage	·0390
„ ox	·375	Veal	·0270
Oats	·131	Apples	·0200
Lentils	·083	White fish	·0170
Haricots	·074	Potatoes	·0180
Egg	·057	Milk	·0150
Beef	·048	Rice	·0150
Wheat bread	·048	Carrots	·0090
Spinach	·045	Burgundy	·0109
Maize	·036	Beer	·0040

Stockman[2] considered these figures were too high, owing to defects in analysis, and gives the following:

100 grammes of milk contain ·2 to ·43 milligramme of iron.
100 „ dried bread contain ·85 to 1·0 milligramme of iron.
100 „ oatmeal contain 3·5 milligrammes of iron.
100 „ yellow ox marrow contain 2·5 to 4·0 milligrammes of iron.
100 „ red ox marrow contain 7·6 to 8·7 milligrammes of iron.
100 „ dried beefsteak contain 3·9 milligrammes of iron.

[1] *Compt. Rend.*, lxxiv. 1355. [2] *Journal of Physiology*, 1895, xviii. 484.

CHAPTER IV

THE AMOUNT OF FOOD REQUIRED

The amount of food required to keep any person in a state of health and bodily equilibrium varies according to many circumstances, such, for instance, as the condition of rest or work, the kind of work, the training, the age, sex, size and weight of the body, restlessness or placidity, and even the individual peculiarities. Viewing the body as an engine, it has been shown, as far as it is possible to be proved, that the laws of conservation of matter and energy are followed in the organism as without. The body loses matter and energy; the matter and energy are not destroyed in the body, but undergo transformation. It may therefore be assumed that, whatever material is used in the body, and however much energy is exhibited or heat evolved by it, both matter and energy have been derived from the food consumed or stored up in the tissues.

Before entering upon a consideration of the theoretical requirements of individuals, some standard dietaries and a few examples of the diets consumed by people of different classes, such as those given in the table on p. 84, will be interesting.

This table shows how the diets of people who have an unrestricted choice of foods differ from one another, as well as the dietaries of armies and navies, and even the so-called "standard diets." The principles which should guide us in arranging a dietary for individuals or groups of people under various circumstances are as follows:

1. **The Food required is Proportional to the Extent of the Surface of the Body.**—The heat of the body is generated by the oxidation of food or tissue-substance. A small animal gives off, weight for weight, more heat than a large one. In experiments upon dogs weighing from 2·25 to 28 kilos, the excretion of CO_2 per hour was practically the same for each square centimetre of surface. Now, a large animal has a smaller cutaneous surface in proportion to its size than a small one, and a small animal a relatively larger surface area than a large one. Small persons have a relatively larger cutaneous area than big people, in proportion to their size and weight, and thin, angular people than persons of a rounded contour. Therefore a small or a thin and angular person loses more heat per kilo of body-weight than a larger and more rounded person; a thin, premature infant more than a plump and well-developed child. After a consideration of many experiments on animals and

human beings, Camerer concluded that an infant expends 100 calories, a child of four years expends 91·3 calories, a child of twelve years expends 57·7 calories, and a man of thirty years expends 42·4 calories, per kilo of body-weight.

Standard Dietaries and Others.	Protein.	Fat.	Carbo-hydrates.	Energy.
	Grammes.	Grammes.	Grammes.	Calories.
Standard Diet: Ranke's	100	100	240	2,310
Moleschott's	130	84	404	2,970
Pettenkofer and Voit's	137	117	352	3,113
Cornet's	120	50	500	3,007
Playfair's	119	51	530	3,025
Parkes's	127	99	397	3,172
The diet of Harvard University boat crew	162	175	449	4,130
Harvard Freshmen boat crew	153	223	468	4,620
Yale University boat crew	145	170	375	3,705
Harvard University boat crew (second observation)	160	170	448	4,075
Harvard Freshmen boat crew (second observation)	135	152	416	3,675
Yale University boat crew (second observation)	171	171	434	4,070
Captain of Harvard crew	155	181	487	4,315
Average of above diets	**135**	**177**	**440**	**4,085**
Football team: Connecticut	181	292	557	5,470
Football team: California	270	416	710	7,885
Professional athlete	244	151	502	4,460
Athletes at Helsingfors	217	259	431	5,070
	182	204	392	4,254
Brickmakers in Connecticut	222	265	758	6,484
Mechanics in United States	154	227	626	5,275
Lumbermen in Maine	206	387	963	8,140
United States Army ration	164	98	600	4,061
,, ,, Navy ration	143	184	520	5,000
English Royal Engineers in active work	144	83	631	3,950
English soldiers on special duty	190	58	510	3,426
	145	150	450	3,503
European soldiers in Batavia	136	79	497	3,000
Mechanics in Germany	139	113	677	4,395
Farm labourers in Austria	159	62	977	5,235
Factory operatives in Russia	132	80	584	3,680
Mechanics in Sweden	189	110	714	4,725

Hence, the amount of heat lost by the body is an important factor in the regulation of the food, and this is governed to a great

extent by area of the surface. Heubner quotes the case of a premature child which did not thrive when its food yielded 110 to 125 calories per kilo of body-weight, and failed to do so until it was fed with 3½ ounces of cow's milk per pound of weight, yielding 150 calories per kilo. The converse holds good: stout persons often have a smaller appetite for food than thin ones, and they need less because they have a relatively smaller surface area, and the amount of heat radiated from their surface is less than in a thin person of the same weight.

2. **The Food must be Proportional to the Weight of the Body.**—The amount required varies, other things being equal, with the weight of the body. The heat of the body is produced by the oxidation of food consumed or stored in the tissues. If the tissues of the body are not to be used for the production of heat and energy, there must be a *minimum* of food consumed to supply the energy utilized by, and the heat radiated from, the body. The heat given off varies with the state of rest or work. *In a state of rest* a man of 154 pounds (70 kilos) gives off 15 cubic feet of CO_2 in twenty-four hours. The production of 1 cubic foot of CO_2 by combustion involves an expenditure of heat equivalent to 160 foot-tons of energy. Therefore $15 \times 160 = 2{,}400$ foot-tons of energy are devoted to the maintenance of the temperature of the body and the performance of the bodily functions during a state of rest. Now, 1 calorie is equal to 1·54 foot-tons of energy, and therefore 2,400 foot-tons is equal to about 1,560 calories, or 22·3 calories per kilo of body-weight. Playfair and Parkes, whose work is still of great value, found that this amount of heat and energy would be yielded by 2·5 ounces of dry albumin, 1 ounce of fat, and 12 ounces of carbohydrate, which was therefore established as the *minimum food requirement*, or "diet for sustenance." According to later investigations, the amount of food required to supply the heat expended per kilo of body-weight by the adult, under various circumstances, is as follows:

Adult Requirement per Kilo.

For sustenance only	23·0 calories.
During rest in bed	25·0 ,,
Sedentary occupation	35·0 ,,
Very light work	40·0 ,,
Moderate work	42·5 ,,
Laborious work	60-120 ,,

3. **The Amount of Food required is Proportional to the Rate of Growth.**—The younger the animal organism, the more rapid is the rate of growth. According to Heubner, the child's body grows seven times more rapidly from one to three months than from six to nine months of age. A child commonly loses a little weight for a few days after birth; but the average increase of weight up to three months is 3·6 pounds; from three to six months, 3·6 pounds;

from six to nine months, 3·4 pounds; and from nine to twelve months, 3 pounds. After the first year the average increase in height and weight is shown in the table on p. 87.

Children do not increase in weight unless the food supplied to them is more than enough to yield the heat radiated from their cutaneous surface. Moreover, an excess of food may not yield an increase in height and weight proportionate to the consumed food. Only a small portion of the food consumed may be retained by the body, there being a limit to the amount of flesh laid on daily. Nevertheless, this general increase in weight and constant growth in height should be anticipated by a provision of food more than enough to supply the heat given off. When food is unrestricted and the appetite is of the healthy juvenile character, there need be little fear on this score; but delicate children have a feeble appetite, and children in public institutions have not a free choice or unlimited supply of food. In arranging dietaries for the latter, it is especially necessary to be liberal.

Anthropometric tables show that—(*a*) Growth is most rapid during the first period of five years after birth, the weight being trebled in the first year, and nearly doubled in the second year. The rate of growth in this period is nearly the same in both sexes, but girls are a little shorter and lighter than boys. (*b*) In the second period, five to ten years, boys grow more rapidly than girls, their weight averaging 2 or 3 pounds more. (*c*) In the third period, ten to fifteen years, girls grow more rapidly than boys; from twelve and a half to fourteen and a half years they are taller than boys of the same age, and from twelve and a half to fifteen and a half years they are 3 or 4 pounds heavier than boys of the the same age. (*d*) In the period from fifteen to twenty years, boys again grow more rapidly than girls; their weight increases at the rate of 6·9 pounds per year, that of girls only 2·75 pounds per year. (*e*) Boys complete their growth in height at twenty-three years of age, but continue to increase in breadth and weight. Girls reach their full height and weight at about twenty years, and their weight is practically stationary for the next five or even ten years. (*f*) After thirty-five years of age, adults increase in weight at the rate of $\frac{3}{4}$ pound (0·34 kilo) per annum, which is not always desirable or advantageous. Up to the height of 67 inches, men are usually heavier than women of the same age; but women of a greater height than 67 inches are as a rule heavier than men of a corresponding height and age, and after middle life their weight may increase very considerably.

4. **The Food should be Proportional to the Age.**—The feeding of infants and children will be dealt with in a separate chapter. Children digest quickly, and their respiratory activity is very great, even when at rest; for this reason they should be allowed as much carbohydrate as an adult, besides an ample supply of protein for tissue formation. The protein, it is shown in that chapter, must be somewhat more for each kilo than is required by an adult.

AVERAGE HEIGHT AND WEIGHT ACCORDING TO AGE.

Males.					Females.				
Age Last Birthday.	Height.		Weight.		Age Last Birthday.	Height.		Weight.	
	Inches.	Millimetres.	Pounds.	Kilos.		Inches.	Millimetres.	Pounds.	Kilos.
1	29·50	749	18·50	8·39	1	27·50	699	18·00	8·17
2	32·50	826	32·50	14·74	2	31·00	787	25·25	11·45
3	35·00	889	34·00	15·42	3	34·00	864	31·50	14·29
4	37·00	940	37·00	16·78	4	36·00	914	36·00	16·33
5	40·00	1,016	40·00	18·14	5	39·00	990	39·00	17·69
6	43·00	1,092	44·50	20·19	6	42·00	1,066	41·75	18·94
7	46·00	1,168	49·75	22·57	7	44·00	1,177	47·50	21·55
8	47·00	1,194	55·00	24·95	8	46·50	1,180	52·00	23·59
9	49·75	1,264	60·50	27·44	9	48·75	1,238	55·50	25·18
10	51·75	1,314	67·50	30·62	10	51·00	1,295	62·00	28·12
11	53·50	1,359	72·00	32·66	11	53·00	1,346	68·00	30·85
12	55·00	1,397	76·75	34·81	12	55·50	1,410	76·50	34·70
13	57·00	1,448	82·50	37·42	13	57·75	1,467	87·00	39·46
14	59·25	1,505	92·00	41·73	14	59·75	1,518	96·75	43·89
15	62·25	1,581	102·75	46·61	15	61·00	1,549	106·25	48·20
16	64·25	1,632	119·00	53·98	16	61·75	1,568	113·00	51·26
17	66·25	1,683	131·00	59·42	17	62·50	1,588	115·50	52·39
18	67·00	1,702	137·50	62·37	18	62·50	1,588	121·00	54·89
19	67·25	1,708	139·50	63·28	19	62·75	1,594	124·00	56·25
20	67·50	1,715	143·25	64·98	20	63·00	1,600	133·50	56·02
20 to 25	67·75	1,721	148·00	67·13	20 to 25	63·00	1,600	134·00	56·25
25 to 30	67·75	1,721	152·50	69·06	25 to 30	62·00	1,575	120·00	54·43
31 to 35	68·00	1,727	160·00	72·58	31 to 35	61·00	1,548	121·00	54·89

It is usually considered advisable to allow children under one year of age about 2 grammes of protein per kilo, whereas only 1·7 grammes is requisite for an adult, according to Voit's standard. In the discussion which has waged around the subject of protein, nobody, so far as I am aware, has attempted to show that 2 grammes of protein per kilo is too much for a young child. The amount needed for growth diminishes gradually, and reaches Voit's standard at the adult period. About half the protein should be derived from animal sources; but where the cost of meat, fowl, fish, eggs, milk, and cheese, is prohibitive, growing children should be given an equivalent amount of peas, beans, or lentils, allowing for the lower coefficient of digestibility of the legumes. Carbohydrates are very necessary, together with fat, in forming the young tissues, to supply the carbon oxidized during their great metabolic activity, and the heat radiated from their comparatively large cutaneous area. For these reasons, the supply of bread, butter or other fat, jam, marmalade, treacle, or honey, should be practically unlimited. (See Feeding of Infants and Children.)

With regard to young adults, the skeleton or framework may cease to grow at twenty to twenty-three years of age; but certain organs do not reach their full development before twenty-five years, and the body does not attain its normal breadth and circumference earlier. It is prudent, therefore, always to consider the young adult as having not completed his physical development until this age is attained, and consequently to feed him abundantly in order to encourage the formation of blood, bone, and muscle. Young females attain complete development a little earlier than males, but they should not be encouraged to eat less on that account than a person of average size and weight. The amount of food required is not quite the same after growth and development are completed; an excess of food over the physical requirements then tends to the accumulation of fat in the subcutaneous and other tissues. It should, however, be distinctly understood that throughout the active period of life the healthy adult requires a definite amount of protein and energy to supply heat and force, to replace tissues worn out, and to keep the organs in good repair and the whole body in sound health.

Variety of food is necessary, for monotony even of the very best kinds leads to satiety, loss of appetite, loathing of food, and subsequent ill-health. Vegetables and fruit are absolutely necessary to the dwellers in towns; but raw fruit and vegetables are not so easily digested as the same kinds are when cooked. Salads (lettuce, watercress, green onions, tomatoes, celery, etc.) are so valuable for the juices contained in them that they cannot be too strongly recommended to those who can digest them. Similar juices are contained in cabbage, cauliflower, spinach, etc., but these are lost in a very great measure by cooking them. Oranges, lemons, bananas, grapes, and strawberries, contain equally valuable juices, and may be eaten raw with advantage to the consumer; but apples,

pears, plums, gooseberries, and many other fruits, are better cooked before being eaten.

A deficiency of food is to be carefully guarded against. Protein, being the most costly food, is the principle most likely to become deficient in the diet. A considerable discussion has arisen upon the amount of protein required daily by the adult after the period of growth is completed, and the matter is more fully considered below. Voit's standard of an allowance of 1·4 to 1·7 grammes of protein and 40 calories per kilo of body-weight has long been accepted as fairly accurate. But the allowance of protein by Voit and others has been seriously impugned, as we shall see later. Until we have a greater experience of the low-protein diet, we should, however, be careful in our judgment. For generations it has been considered that protein starvation is the cause of much ill-health and misery, and this position cannot lightly be given up by the physician. **Protein starvation** is not uncommon amongst many poor but respectable people who for a long time have to live upon a diet in which "tea and bread and butter" figure prominently, with an occasional bloater or other appetizer. Such a diet, although it may yield enough heat to supply the demands of the body according to scientific requirements, does not give the consumer strength and endurance. The general principles laid down, therefore, should guide us; and where the cost of meat, fowl, fish, eggs, or milk, is prohibitive, the freer use of peas, beans, lentils, and nuts, is strongly recommended. In spite of scientific investigations as to the bodily requirement of persons in adult life, and standards for the amount which they should consume, we are bound to admit there may also be a personal equation which will upset the calculation, and that scientific figures can only be given for averages, unless a similar investigation is made upon each individual.

Overfeeding must also be guarded against. In youth and early adult life an excess of food may be disposed of by quick digestion and speedy assimilation, great metabolic activity, and greater physical exercise, whereby the excess consumed is used up and eliminated. But when middle life is attained the body is less active; the active interest in cricket, football, golf, and other out-of-door games, is dropped, consequently less food is metabolized, and an "undesirable balance" remains against the consumer. A certain amount of the surplus may be stored up in the body as protein, glycogen, and fat, and by-and-by the individual becomes obese or corpulent. There are some persons, even though they continue to eat large meals, lead an inactive life, follow a sedentary occupation, and live in warm rooms, "lapped in luxury," who never put on flesh; they seem to have no power of forming fat in their body or of accumulating it; but the "undesirable balance" causes other troubles, such as bilious attacks, migraine, headache, lethargy, diseases of the liver, kidneys, bloodvessels, and favours the production of rheumatism, gout, gravel, and kindred affections. In a third class of persons a combination of the two groups of

trouble occurs. Therefore an excess of food in adult life encourages or causes the diseases to which people are liable in middle and advanced age. Again, the personal equation should be taken into account; it is probable that the individual requires a smaller quantity of food than that prescribed by standard dietaries; or it may be that one of the principles should be reduced in amount. Thus, the protein may need to be lowered to two-thirds of the standard, and the fat to about half the amount, thereby reducing the total calorie value. In other cases only the carbohydrate needs to be lowered.

The power of the entire muscular system declines after forty years of age; from this period, not only the skeletal muscles, but the involuntary muscles of the heart and other organs, gradually diminish in vigour. In every part of the organism there is a disposition to lay on fat rather than to form new materials characteristic of the organs; and in every organ there is a tendency to replace the normal matrix by a deposition of amorphous tissue, which may undergo calcareous degeneration. These two characteristics of increasing age, calcareous and fatty degeneration, are indicative of a decline in the nutritive processes. The metabolism everywhere becomes feebler and slower; sensory impulses pass with increasing slowness to and from the brain; the sensations are blunted, the molecular energy of the impulses diminished, and everywhere there are indications of the diminished ability to metabolize the amount of food given in the standard diets for adults. This matter is more fully considered in the chapter on Food for the Aged.

5. **The Influence of Sex on the Amount of Food required.**—The general rule that the food should vary with the size and weight of the individual holds good when considering the food of persons of different sexes. But the influence of size is far less than that of the inborn individual characteristics of the organism giving rise to the personal equation of metabolism. The smaller metabolism of a woman, leading to the consumption of a smaller amount of food compared with that of the average man, should be regarded in the light of the personal equation involved in the sex of the individual rather than with reference to the smaller average weight and size of a woman. This is illustrated by the food of an active man and woman of about the same age and weight, whose nutritive and nitrogenous equilibrium was maintained upon the following daily amounts:

Man: Protein 100, fat 70, carbohydrate 400, grammes; calories 2,700.
Woman: Protein 60, fat 67, carbohydrate 340, grammes; calories 2,263.

With the exception of the differences in metabolic activity, there appears to be no reason for any variation in the food owing to the sex of the consumer; and Atwater established the principle that the allowance for a healthy woman should be 0·8 of that for a man. It may, however, be stated as a general rule that a woman

requires about the same amount of protein and energy per kilo of body-weight as a man under the same circumstances. The amount of energy required to produce a definite quantity of work is no less when the work is performed by a woman than when it is done by a man; therefore the supply of fuel should not be less. On the other hand, it frequently happens that the expenditure of energy to produce a definite amount of work by a woman is greater than that expended by a man in doing the same work.

There are other circumstances in the life of the female which influence the demand for food. It is said that the internal secretion of the ovaries facilitates the oxidation of carbohydrates and the organized phosphorus of the food. Females are subject to a wave of metabolic activity which reaches its climax just before each menstrual period; during the rise of this wave there is an increase in the nitrogen metabolism, but a diminution in the carbon metabolism; at the same time there is a formation of new blood-cells, an increasing amount of nerve force and general vigour, and a feeling of *bien-être*. A woman gains 1·5 to 5 per cent. of her total weight during the intermenstrual period, which is partly due to diminished excretion of carbonic acid and water. But during the menstrual period there is a corresponding loss of weight, owing to an increased excretion of carbonic acid and water, although the protein metabolism is diminished, as shown by a diminution in the excretion of nitrogen during " the period."

There are few reports of experiments to show the effects of pregnancy upon metabolism. But deductions drawn from such experiments on animals are applicable to the human being. Reprev found that during pregnancy the organism assimilates more food and rejects less. The cleavage of protein is greater during pregnancy and lactation than during sexual rest; but less urea and phosphates are excreted in the urine than under normal conditions, and the excretion diminishes as pregnancy proceeds. In other words, assimilation is intensified while excretion is diminished, and nitrogen and phosphorus are stored in the body. Hagemann also found that during pregnancy and lactation more nitrogen is retained to meet the unusual demands of the organism. Oddi and Vicarelli studied the influence of pregnancy on the respiratory quotient; they arrived at the conclusion that gestation is characterized by an increased combustion of carbohydrates in the tissues, but that part of the carbon and nitrogen of the food is utilized in the formation of new tissues—in other words, for the nutrition and development of the fœtus.

In this condition, therefore, an allowance of food must be made to provide for the growing embryo. At about the middle term of pregnancy the fœtus weighs 0·5 kilo, in the seventh month from 1 to 1·5 kilos, in the eighth month from 1·5 to 2·5 kilos, and in the last month from 3 to 5 kilos. The fœtus increases in weight during the last three months at the average rate of 21·5 to 26·5 grammes per day, with a maximum of 65 grammes per day during the last

month. But the woman also increases in weight during the pregnancy, in spite of the increased combustion of non-nitrogenous elements; for the uterus and breasts increase in size, and there is usually a deposition of fat in the adipose tissue. An increase of food, therefore, is demanded, and it is considered that for the last three months of pregnancy a daily allowance of 3 grammes of protein, 3·5 grammes of fat, and 0·75 gramme of mineral salts, *per kilo of body-weight*, with sufficient carbohydrate to assist in meeting the increased metabolism of carbon, should form the standard to guide us in prescribing food for this period. This means practically that the woman should consume double the ordinary amount of meat, and have an unlimited quantity of bread, butter, etc.

The gain of weight during pregnancy is usually lost in the period of lactation, and the body is likely to emaciate unless the standard of food be kept up to something near that allowed for the last three months of pregnancy. A woman secretes 700 to 800, or even 1,000, c.c. of milk daily, containing roughly 15 to 21 grammes of protein, 26 to 35 grammes of fat, 45 to 60 grammes of sugar, and from 490 to 660 calories. The energy of producing the milk has also to be taken into account. The total increased expenditure of energy on the part of the mother may be anything from 600 to 1,000 or more calories. An extra allowance of food is required for the nursing mother, and it must be sufficient to protect her from the debilitating effect of the great drain cn her system. The kind of food consumed by the mother is of importance, although the proportion of *solids-not-fat* in her milk is only slightly dependent upon it. The consumption of carbohydrates—*e.g.*, starch—does not increase the yield of milk nor the proportion of milk-sugar. The consumption of fat has little influence upon the amount of fat in the milk; the quantity of fat in the milk is greatest when most protein is consumed, least when starch is consumed. The absolute and relative proportion of protein in the milk, although ultimately derived from the food, is not directly proportional to the protein consumed; it increases a little with a large consumption of meat, and decreases a little during fasting.[1] Cotton-seed cake increases the secretion of milk in cattle; and *lactagol*, a preparation of cotton-seed, increases the protein and fat in human milk. Milk is a genuine secretion of the mammary gland, and not a mere filtration from the blood. It depends upon an active growth and metabolism of the cells of the acini. The food therefore must be such as will stimulate metabolism and supply the materials used by the body for its production. All the circumstances being considered, the conclusion is arrived at that an extra allowance of meat is demanded by the body; and cow's milk, which is largely similar to it, is capable of supplying most of the constituents of the secretion. The daily allowance of 3 grammes of protein, 3·5 grammes of fat, 07·5 gramme of salts, per kilo of body-weight, and as much carbohydrate as

[1] Bulletin 45, p. 136, U.S. Department of Agriculture.

seems to be desired, is now equally as important as during the last months of pregnancy.

6. **The Food should be Proportional to the Work to be done.**—Food is fuel. The amount of food required by an adult depends more upon the amount of work done by the body than any other factor. This dictum follows as a necessary corollary to the demonstration that the body is a machine. The more energy is expended by the machine in doing work, the more fuel must be consumed to yield that energy. Zuntz calculated that the amount of energy expended by a man following a sedentary occupation, such as writing and reading, was from 30 to 50 per cent. more than would be expended during absolute rest of his body, and this was again increased 30 per cent. by moderate work, and still more by severe work; and he estimated the daily expenditure of energy to be as follows:

Expenditure of Energy per Day.

During absolute rest	1,700 calories.
Sedentary life in a room	2,200 to 2,250 ,,
Doing moderate work	3,000 to 3,250 ,,

The work of the human machinery is divided into internal and external work. The **internal work** of the organism is performed by the organs of digestion, circulation, respiration, and the nervous system in maintaining the temperature of the body, the tone of the muscular system, supplying the secretions and excretions. The performance of all these functions is essential to life, whence they are called the "vegetative functions." The energy expended in the performance of some of these functions can be estimated. Thus, the work of the heart alone amounts to 70,000 or 75,000 kilogramme-metres, involving an expenditure of 176·5 calories of energy per diem; that of the organs of respiration 12,000 to 20,000 kilogramme-metres; and the work of the other internal organs requires a proportionate expenditure. The internal work is going on even during absolute rest, and, according to Zuntz, the energy expended by the whole body is 1,700 calories. Atwater found, by the observation of people in a respiratory calorimeter, that a subject awake and sitting perfectly still used 80 per cent. more energy than the same subject during sleep; that a man awake and sitting perfectly still, controlling all his movements as much as possible, could reduce his expenditure one-third, as shown by the amount of material oxidized or the expiration of CO_2; that on days when food was taken, a man excreted 20 per cent. more CO_2 than he did on fasting days, and this oxidation of material he considered was due to the expenditure of energy to carry on the work of digestion and assimilation.

External Work.—A much greater increase in the amount of CO_2 expired and heat radiated from the body occurs during exercise of the voluntary muscles—which is denominated "work." Atwater found that a man in the respiratory calorimeter evolved during two hours' rest 150 calories; when working a stationary bicycle

for two hours, 500 calories; and when working the same bicycle against resistance for the same time, 1,000 calories. It is evident, therefore, that food must be supplied in proportion to the work to be performed, otherwise the substance or tissues of the body will be consumed as fuel to supply the energy expended. It is surprising how readily the organism makes use of its own substance. There is no doubt, however, that the glycogen stored up in the liver and muscles is first used up; and when that is exhausted, if the supply of food is unequal to the fuel consumed, the organism makes use of the protein and fat of the tissues to make up the deficiency. Some idea of the tissues consumed when food is deficient may be gleaned from a case of starvation. Foster[1] quotes the case of a cat of known weight which was starved for thirteen days. An analysis of its body was made after death. During the period of starvation it lost 734 grammes of solid substance, of which 248·8 grammes was fat, 118·2 grammes was muscle, and the remainder was derived from the organs of the body. The percentage loss was determined to be as follows:

LOSSES DURING STARVATION.

The adipose tissue	lost	97·0	per cent.	of its weight.
The spleen	,,	63·1	,,	,,
The liver	,,	56·6	,,	,,
The muscles	,,	30·2	,,	,,
The blood	,,	17·6	,,	,,
The nervous system	,,	00·0	,,	,,

These figures show that the greatest loss falls upon the accumulated fat, seeing that the adipose tissue disappears almost entirely during starvation. Next to this the glandular organs, especially the spleen and liver, are drawn upon for fuel; then the skeletal muscles; while the blood suffers proportionately to the general waste. It might be assumed from these figures that metabolism is the most active in the adipose tissue, and next in the liver and spleen, but there is no warrant for that assumption. The loss of cardiac and nervous tissue during starvation is exceedingly small; but we cannot, on that account, conclude that their metabolism is feeble. On the other hand, they may undergo rapid metabolism, and yet be preserved from wasting by drawing upon other tissues to support their nutrition. The enormous loss of adipose tissue during deficient supply of nutriment is due to the fact that this tissue is a storehouse for fat, which it readily yields on demand. The great loss by the liver and spleen indicates that they also serve as storehouses. The muscles are storehouses of glycogen, and from this source muscular energy is first derived. During the period of starvation the urine of the cat contained 27·7 grammes of nitrogen; the amount of muscle wasted during the same period contained 15·2 grammes of nitrogen; therefore more than half the

[1] "Textbook of Physiology," ii. 789.

nitrogen utilized during the starvation period was derived from the metabolism of muscular tissues. The muscles, however, were not the only source of nitrogen, some having been derived from the metabolism of nitrogenous fats, and some from the nitrogenous materials of the bones and spleen. The amount of nitrogen excreted falls very rapidly during the first day or two of abstinence from food—that is, while stored proteins are being consumed—and then diminishes very gradually. The heat-value of 1 gramme of body-protein is 5·65 calories, and 1 gramme of body-fat 9·54 calories.[1]

Energy.—We must now inquire how the demand for energy is varied by rest and work. It will be proper, first of all, to give a standard balance-sheet of the food and energy. The following, part of which is previously given, will answer our purpose. Experiments were made by Ranke, a physiologist, upon his own body. His duties as a physician and lecturer involved but a small expenditure of mechanical energy in external muscular work, and he was able to maintain his weight (75 kilos) and nitrogenous equilibrium upon a diet containing 100 grammes of protein, 100 grammes of fat, and 240 grammes of carbohydrate, yielding 2,310 calories. The balance-sheet given on p. 96 shows the income and expenditure of the body in matter and energy.

Now, 2,310 calories of heat, when transformed into mechanical work, is equivalent to 980,000 kilogramme-metres, or in round numbers *one million*. The energy which is expended in work was estimated by Parkes in the form of foot-tons. His figures have not been impugned by more recent investigations, and therefore are given below as illustrating the amount of energy expended in various forms of work:

THE ENERGY EXPENDED DAILY IN WORK.

	Foot-Tons.	Kilogramme-metres.	Calories.
Light work, one day	300·0	92,580	195·0
Moderate work, one day.. ..	324·0	100,000	210·0
Hard work, one day	484·0	150,000	315·0
Walking, one mile	17·5	5,400	11·4
,, four miles	70·5	21,756	45·8
Carrying sixty pounds one mile	25·0	7,715	16·2
,, ,, ,, four miles	100·0	30,860	65·0
Pedlar's day's work	303·0	—	196·5
Convict's day's work	310·0	—	200·0
Dock labourer's day's work ..	315·0	—	204·0
Pile-driver's day's work	332·0	—	216·0
Road-maker's day's work ..	352·0	—	229·0
Turning a winch, day's work ..	374·0	—	250·0

A man walking on a level surface at three miles an hour does work equal to raising his own weight, plus the weight he carries,

[1] Bulletin 69, p. 46, U.S. Department of Agriculture.

I. MATTER.

Income.				Expenditure.		
Food.		Nitrogen.	Carbon.	Excretions.	Nitrogen.	Carbon.
	Grammes.	Grammes.	Grammes.		Grammes.	Grammes.
Protein	100	15·5	53	Urea 31·5, uric acid ·5	14·4	6·16
Fat	100	—	79	Fæces	1·1	10·84
Carbohydrate	240	—	93	Respiration, CO_2	—	208·00
Total	440	15·5	225	Total	15·5	225·00

II. ENERGY.

Energy of the Food: Protein 100 × 4·5, Fat 100 × 9·0, Carbohydrate 240 × 4·0; Total, 2,310 Calories.

Heat produced by Oxidation of Food.			Heat discharged.	
	Per Cent.	Calories.		Calories.
By metabolism in muscles	85	1,964	By warming water in food: 2·6 kilos × 25° C.	65
By metabolism in glands and brain	10	231	By warming air in respiration: 16 kilos × 25° C. × ·24	96
By metabolism in other organs and tissues	5	115	By evaporation in lungs: 630 grammes × ·582	366
			By radiation and evaporation from the skin	1,733
Total	—	2,310	Total	2,310

through one-twentieth of the distance walked. At this particular rate of walking *the coefficient of traction* or resistance is one-twentieth. At quicker rates of speed it diminishes, and approaches unity; *e.g.*, at eight miles an hour it is barely one-tenth. The amount of work done, in foot-tons, is calculated as follows: Let W = weight of the man; W′ = the weight carried; D = the distance walked in miles; and C = the coefficient of traction. Then—

$$\frac{(W + W') \times D \times 5280}{2240} \times C = \text{foot-tons.}$$

It is thereby found that a man weighing 160 pounds, carrying no weight, and walking seventeen miles at three miles an hour, performs work equal to about 300 foot-tons.

The more active the body, the greater is the production of heat; and more food is oxidized during the performance of work than is transformed into mechanical energy. The experimental evidence obtained by Atwater and Benedict upon metabolism is of great value as illustrating this point (see table on p. 98).

It is evident that the supply of food must be in proportion to the work done; and this is in accord with experience that the food should vary as the kind and amount of work done. Examples are as follows:

(1) *Intellectual Work.*—Ranke, a professor, found that a diet yielding 2,310 calories was sufficient to maintain him in health, to keep his organism in nutritive equilibrium, and maintain his nitrogen balance, while following his ordinary avocation, which was chiefly intellectual. He estimated that 15 per cent. of the energy of his food was expended in doing muscular work.

(2) *Ordinary Light Work* causes a loss of about 3,000 calories, or units of heat, by the body, of which little more than 15 per cent. is spent in the performance of muscular work.

(3) *Moderate Muscular Work* performed for a period of eight hours causes the body to lose about 3,500 to 4,000 calories, about 20 per cent. being mechanical energy.

(4) *Severe Muscular Work* during the same period causes from 4,500 to 6,500 calories, or units of heat, to be radiated from the body. In all manual labour the best and most economical results are obtained when certain groups of muscles are *trained* for their work. An untrained man becomes readily exhausted, and gives out a greater amount of heat in proportion to the work done. The trained worker can do the same amount of work much more easily, with less exhaustion, and with a smaller expenditure of energy or loss of heat. Walking, running, rowing, cycling, are examples of muscular work where the muscles can be trained to work with economy and the greatest possible advantage. Football and navvy-work cannot be done with the same economy of energy, because most of the muscles of the body are brought into action.

Experimental investigations in a respiratory calorimeter and

EXPERIMENTS SHOWING THE AMOUNT OF FOOD REQUIRED DAILY.[1]

Subject and Nature of the Experiment.	Income: In Digested Food.				Outgo: In Material oxidized.						
					Per Person.		Per Kilogramme of Body-Weight.		Per Square Metre of Body-Surface.		Energy transformed into Mechanical Work.
	Nitrogen.	Carbon.	Energy.	Protein: N×6·25.	Protein.	Energy.	Protein.	Energy.	Protein.	Energy.	
	Grammes.	Grammes.	Calories.	Grammes.	Grammes.	Calories.	Grammes.	Calories.	Grammes.	Calories.	Calories.
(a) *Rest Experiments* :											
J. C. W.: Fasting, 5 days ..	—	—	—	—	**82·0**	**2,250**	**1·08**	**29·6**	**37·1**	**1,018**	—
E. O. (13): Average for 42 days ..	17·4	230·5	2,443	108·8	112·5	2,282	1·61	32·6	53·8	1,092	—
A. W. S. (4): Average for 9 days	14·5	220·5	2,375	90·6	94·4	2,305	1.35	32·9	45·2	1,103	—
J. F. S. (4): Average for 12 days	15·2	223·7	2,352	95·0	98·1	2,119	1·51	32·6	49·3	1,065	—
J. C. W. (1): Average for 4 days	14·8	214·3	2,274	92·5	98·8	2,357	1·30	31·0	44·7	1,067	—
Average of 22 experiments, 67 days	16·5	227·0	2,408	103·1	106·9	2,260	1·54	32·5	51·4	1,087	—
(b) *Work Experiments* (8 *hours daily*) :											
E. O. (3): Average for 12 days ..	17·7	324·0	3,513	110·6	110·0	3,892	1·57	55·6	52·6	1,863	214
J. F. S. (6): Average for 18 days	15·0	302·9	3,245	93·7	102·5	3,560	1·58	54·8	51·5	1,789	233
J. C. W. (14): Average for 46 days	15·4	417·2	4,416	96·3	109·4	5,120	1·44	67·8	49·5	2,317	546
Average of 23 experiments, 76 days	15·7	375·4	3,996	98·1	108·1	4,556	1·49	62·9	50·5	2,129	419
J. C. W.: Work 16 hours in 1 day	—	—	—	—	114·4	9,981	1·51	131·3	51·8	4,526	1,482

[1] Bulletin 136, pp. 124-126, Experimental Station Report, U.S. Department of Agriculture.

common experience have shown that the muscular work done by an individual cannot be increased over a long period without a corresponding increase of food. Work to the amount of 100,000 kilogramme-metres can be sustained day after day without much inconvenience and without loss of weight; but work represented by 124,000 kilogramme-metres cannot be kept up very long without a considerable increase of diet, and even then there may be a loss of weight and vigour. It has also been shown that the amount of food must be more than enough to supply the extra amount of energy expended in labour. A reference to a few other observations upon this matter may be of interest:

(*a*) **Men.**—(1) Zuntz found that men yield from 30 to 35 per cent. of their energy in the performance of muscular work. (2) Atwater found that an individual doing ordinary muscular work does not expend more than 20 per cent. of the energy of his food in mechanical labour; *e.g.*, when working a stationary bicycle in a respiratory calorimeter, out of 100 calories, or units of heat, produced by the body, only 20 calories, or one-fifth, were transformed into energy by working the pedals. The proportion was somewhat greater with light work and less with severe work, and greater, again, when the work was prolonged. (3) Ranke found in his own case, representing very light work, that only 15 per cent. of his energy was spent in the form of muscular work.

(*b*) **Horses.**—Kellner and Wolff found that horses reproduce 35 per cent. of their energy in the form of work.

(*c*) **Dogs.**—Zuntz found that dogs can reproduce 35 per cent. of their energy in work.

(*d*) **Engines.**—(1) An ordinary oil or steam engine yields 15 to 22 per cent. of the energy from fuel consumed, as mechanical work. (2) The best oil-engine will yield not more than 33 per cent. of the energy of its fuel, in mechanical work.

When calculating the amount of food required for additional work done, Atwater's estimates are of service. His figures show that 20 per cent. of the food would be expended in mechanical work, and 80 per cent. dissipated as heat, and that at least five times the number of calories must be provided to yield the requisite energy for a given amount of work. When hard work is being done, about 15 per cent. of the energy is derived from the food, and therefore the allowance should be six times the amount of mechanical work to be done. When the work is very exhausting or prolonged, especially if carried out under adverse circumstances, so that tired muscles are called upon to contract, the efficiency of the machinery is lowered; it does not get so much energy out of the food—or, rather, a much larger calorific expenditure occurs in producing the work—and considerably more than 3,500 calories will be expended. This probably accounts for the large consumption of food by brickmakers, lumbermen, navvies, and scavengers, which has been recorded by various authorities. By using Atwater's figures for the amount of energy transformed into mechanical work

and the proportion derived from food, we are able to make the following calculation:

Calculation of Food required for Work.

		Calories.
Required for sustenance ..	.. ..	1,905
For light work ..	.. 1,905 + (195 calories × 5)	= 2,880
For moderate work ..	.. 1,905 + (210 ,, × 5)	= 2,958
For hard work ..	.. 1,905 + (315 ,, × 5)	= 3,480
,, ,, ,, ..	.. 1,905 + (420 ,, × 6)	= 4,425
For very hard work ..	.. 1,905 + (546 ,, × 6)	= 5,181
,, ,, ,, ,, ..	.. 1,905 + (600 ,, × 6)	= 5,505
,, ,, ,, ,, ..	.. 1,905 + (1,000 ,, × 6·5)	= 9,405

The necessity for increasing the allowance of food in proportion to the work the body is expected to do has always been recognized by scientific men, and the table on p. 101 gives the figures of Playfair,[1] with the corresponding amounts of matter and energy in grammes and calories estimated by Rubner's factors.

Some examples of the food known to be consumed by people are given in the table on p. 102.

Many investigators have made observations upon the food consumed by individuals who were allowed a free choice of food, and, finding that, with diets having the values given above, such persons' nutrition was fairly normal and their nitrogen balance in a state of equilibrium, they concluded that the diet fairly well represented the amount required by these persons.

The list of examples of food consumed given on p. 102, compiled from data collected in Europe, Asia, and America, shows that, when Europeans and Americans are free to choose their own food, they seldom select what will yield less than 100 grammes of protein per diem. It is, in fact, quite unusual for Europeans and Americans of the male sex to consume less than 90 grammes of protein per diem when the choice of food rests with the individual. There are many thousands of individuals who perforce must consume a smaller quantity of protein, because meat, fish, fowl, milk, eggs, and cheese, are dearer than bread, potato, rice, oatmeal, etc. But when all the circumstances were taken into consideration by Voit, it was established by him as a rule that *the amount of protein required daily was from* 1·4 *to* 1·7 *grammes per kilo of body-weight,* and that 119 grammes of protein and 2,800 to 3,000 calories were sufficient to meet the requirements of a man of 154 pounds (70 kilos) when doing light work. Maurel,[2] who has devoted much attention to the subject, found that, to maintain the body in nitrogenous equilibrium when no muscular work is being performed, the adult in full health and vigour requires 1·5 grammes of protein and 35 to 38 calories of energy per kilo of body-weight, and that any muscular work must be met by an increased supply of nutriment.

[1] Lectures at the Royal Institution, 1865.
[2] *Rev. Soc. Sci. Hyg. Alim.*, 1906, p. 763.

PLAYFAIR'S TABLE OF REQUIREMENTS FOR WORK.

Subject and Condition.	Protein.	Fat.	Carbo-hydrates.	Salts.	Dynamic Value.	Protein.	Fat.	Carbo-hydrates.	Salts.	Energy.
	Ounces.	Ounces.	Ounces.	Ounces.	Foot-Tons.	Grammes.	Grammes.	Grammes.	Grammes.	Calories.
Subsistence diet.. ..	2·230	·840	11·69	—	2,453	63·25	22·0	330	—	1,820
Moderate work	4·075	1·557	18·80	1·963	4,072	115·00	44·0	534	14·00	3,070
Soldiers: During peace ..	4·215	1·397	18·69	·714	4,026	120·00	40·0	530	19·25	3,037
Infantry in the field ..	5·410	2·410	17·92	·680	4,458	154·00	68·0	510	19·07	3,374
Royal Engineers in the field	5·080	2·910	22·25	·930	5,232	144·00	82·5	610	26·36	3,858
English sailors	5·000	2·370	14·39	—	3,911	142·00	65·0	410	—	3,067
Navvy	5·640	2·340	20·41	—	4,839	160·00	67·0	578	—	3,650
Prisoners: Under 7 days	1·800	·480	10·71	—	1,938	51·00	14·0	304	—	1,626
Under 21 days ..	2·448	·608	14·80	—	2,650	68·00	17·0	425	—	2,179
Light labour	3·508	·315	16·72	1·715	3,577	100·00	9·0	470	50·00	2,420
Industrial labour ..	3·710	1·562	17·31	1·616	3,787	105·00	44·0	495	46·00	2,870
Hard labour	4·075	1·557	18·80	1·963	4,072	116·00	44·0	534	14·00	3,075
Undergoing punishment	1·296	·256	8·16	·368	1,541	36·00	7·1	230	10·60	1,154

EXAMPLES OF FOOD ACTUALLY CONSUMED.[1]

Subjects of the Observation.	Protein.	Energy.
	Grammes.	Calories.
Tennessee students, 5 clubs, average ..	92	3,545
Connecticut students, 5 clubs, average ..	106	3,280
Maine students, 5 clubs, average ..	121	4,269
Missouri students, 3 clubs, average ..	96	3,560
Knoxville students, 1 club	66–123	4,545
Japanese students, average	94	2,712
Professor	123	2,343
French physicians, average	92	1,852
Women students, average	85	2,696
German physicians, average	110	2,510
Professor	100	2,310
New York business men, average ..	109	3,235
Working-Class Averages :		
New York, 19 families	106	3,030
Philadelphia, 26 families	109	3,235
Chicago, 25 families	119	3,425
New Jersey, 1 family	100	3,285
Virginia, 19 families	109	3,745
Tennessee, 3 families	101	3,660
Connecticut, 9 families	106	3,420
Indiana, 1 family	90	3,285
California: Farmers' families	97	3,515
Farm labourers	144	4,100
Canada: Farm labourers	108	3,585
Factory operatives	127	4,415
Atwater's standard diet { Without work	90	2,700
Atwater's standard diet { Light work ..	112	3,000

Subjects of the Observation.	Protein.	Energy.
	Grammes.	Calories.
English weavers	151	3,475
Tailor	131	3,053
Lacemaker	120	3,200
Mechanics	140	3,500
Ploughman	140	4,000
Peasants	69	2,850
Navvy	172	4,050
Dressmakers	56	1,800
Female basket-maker	90	2,200
Sempstress	60	1,810
Schoolmistress	80	2,000
Female clerk	85	2,020
Scotland: 15 poor families	107	3,233
Irish peasants	70	2,800
Germany: Physicians	92	1,852
Operatives and labourers	143	4,170
France: Operatives and labourers ..	140	3,800
Sweden: Operatives and labourers ..	161	4,080
Russia: Operatives and labourers ..	113	3,061
Japan: Poor people	71	2,026
Jinriksha man	158	5,050
Physician	59	2,580
Malay: Student	96	2,723
Male servant	73	3,151
Bengal College: (*a*) Bengalee students ..	67	2,914
(*b*) Bengalee students	44	1,292
(*c*) Eurasians	87	2,420
Atwater's standard diet { Moderate work	125	3,500
Atwater's standard diet { Severe work ..	150	4,500

[1] Bulletin 52, p. 24. U.S. Department of Agriculture, and other sources.

Thus, *a man weighing 154 pounds (70 kilos) would require for maintenance 105 grammes of protein and 2,450 to 2,660 calories of energy; and a woman of 132 pounds (60 kilos) would require 90 grammes of protein and 2,100 to 2,280 calories of energy.* These figures are probably near the mark.

In a discussion on "The Food Requirements for Sustenance and Work" at the 1910 meeting of the British Medical Association,[1] Colonel Melville gave an example of men doing a measured amount of work with a measured quantity of food. Twenty soldiers walked for periods of five and six days an average of twelve to thirteen miles, carrying their kit, the weight of which averaged 54 pounds (24·5 kilos). The average weight of the men was 141 pounds (64·15 kilos). The expenditure of energy was calculated from Zuntz's factors: For every kilo transported horizontally at the rate of 94 metres (102 yards) per minute the expenditure was 0·0006 calorie; and for every kilo raised 1 metre vertically the expenditure was 0·0075 calorie; whence it was determined that the average expenditure in walking one mile and carrying 54 pounds over an ordinary give-and-take road was 90 calories, and the total daily expenditure in external or mechanical work amounted to 1,034 calories. Melville therefore estimated that the total energy expended by these men was as follows:

1. ENERGY EXPENDED BY MARCHING SOLDIERS.

	Calories.
(*a*) Energy spent in sedentary occupation (Zuntz)	2,200
(*b*) Energy spent in work of camp life, and in playing quoits and football	800
(*c*) Energy spent in walking and carrying load	1,034
Total average daily expenditure	4,034

The march was done on six days continuously; then one day's rest intervened before the second period of five days' walking completed the work done. The food consumed was as follows:

2. FOOD CONSUMED BY EACH SOLDIER PER DAY.

	First Week.	Second Week.	Average.
	Grammes.	Grammes.	Grammes.
Proteins	190	145	168
Carbohydrates	510	450	480
Fat	58	110	84
Calories	3,426	3,503	3,481

Unavoidable waste, 10 per cent.; net calorific value, 3,140.

There was therefore, according to the calculation for work done, a deficiency of 890 calories in the food. Is this supposed deficiency

[1] *Brit. Med. Jour.*, 1910, ii. 1337-1340.

an actual deficiency? The allowance of protein in the first week (190 grammes) was distinctly high, and 30 per cent. above the amount allowed in barracks; at the same time the carbohydrate was increased 25 per cent. But there was an actual deficiency, as shown by the loss of body-weight by the men. The loss of weight averaged 2·68 pounds (1·22 kilos) for the maximum period, and 2·2 pounds (1 kilo) for the whole period. During the last five days of the experiment there was an average daily loss of 234 grammes, or just over half a pound. If the material lost consisted only of fat, it would yield 234 × 9·3 = 2,176 calories, whereas the estimated loss was 890 calories. It is evident, therefore, that the muscles suffered loss as well as the adipose tissue. In a case of starvation under the observation of Benedict, previously quoted, the loss of energy measured by the calorimeter was 1,696 calories daily, and the loss of weight averaged 18½ ounces (526 grammes) daily; the loss probably consisted of 69·5 grammes of protein, 139·6 grammes of fat, and 23 grammes of glycogen. If the loss of weight by the soldiers under observation be assumed to fall on the tissues in the same proportion, the energy provided by the consumption of their own tissues should have been as follows:

$$\frac{\text{Loss by soldiers} = 234 \text{ grammes}}{\text{Loss by case of starvation} = 525 \text{ grammes}} \times 1{,}696 \text{ calories} = 756 \text{ calories.}$$

The agreement with the estimated deficiency is pretty close. Considering the amount of protein consumed, Melville found the allowance of 190 grammes—practically 3 grammes per kilo of body-weight—should be the *maximum* allowance; but if this erred on the side of generosity, he had no hesitation in saying that the allowance of 145 grammes, or 2·25 grammes of protein per kilo, should be the *minimum* allowance for work—*i.e.*, it is as low as it is *advisable* to go—and might well be increased when hard work is demanded of the men, especially with exposure to the hardships of camp life and the inevitable vicissitudes of active service.

Chittenden, however, made a series of most careful observations on persons who consumed a low protein diet; it included not more than half the amount prescribed by the standard diets or that consumed by the majority of people who have free choice of food. He did this because he was not satisfied that the standards drawn up by Voit, Atwater, and other observers, from a consideration of the dietetic habits of the people, represented the true physiological requirements of the body. He aimed at a demonstration of the true physiological nutritive requirements of the body, which he based upon the following four points: The maintenance of (1) the nitrogen equilibrium; (2) the physiological equilibrium, or body-weight; (3) the physiological efficiency; and (4) the ability to resist disease.

Chittenden was induced to undertake his series of observations by Horace Fletcher, who for five years practised a rigid economy in diet in association with elaborate and prolonged mastication

(see Fletcherism). Fletcher believed that prolonged and exceedingly careful mastication of the food would reduce the amount required by the body to about one-half the standard diets. At the end of five years he was able to perform the trying and arduous work of a University oarsman on a diet possessing only 40 per cent. of the protein and about 50 per cent. of the calorie value of the standard diets; nevertheless he was in sound health, and his efforts as an oarsman compared favourably with those of men who consumed the ordinary diet.[1]

Chittenden then experimented with a group of athletes whose nitrogen consumption was reduced to 55 grammes of protein daily.

A second group consisted of soldiers who lived for five months with a nitrogen metabolism of 7 to 8 grammes per day, and for whom an allowance of 50 grammes of protein daily was sufficient for the needs of the body, the calorie value of the food remaining as usual.

A third group consisted of professional men, who were under observation for a period of six to nine months. In these it was shown to be possible to maintain the nitrogen balance in equilibrium, the body-weight undiminished, and the organism in health and vigour, during the entire period, with a daily metabolism in the different persons of 5·4 to 8·99 grammes of nitrogen—that is, with the use of 34 to 56 grammes of protein daily.

As a result of these experiments, Chittenden believes that 0·1 to 0·12 gramme of metabolizable nitrogen, or 0·625 to 0·75 gramme of protein, per kilo of body-weight, represents the protein requirements of the body in the ordinary conditions of life, and an allowance of 50 to 60 grammes of protein daily—*i.e.*, about half the usual quantity of absorbable protein—is an ample provision for a man weighing 60 to 70 kilos.

These amounts are considered by Chittenden to satisfy the physiological requirements of the body, which he establishes from the following considerations: All but a very small part of the protein taken as food rapidly passes out of the body as urea, the excretion of urea being in proportion to the amount of protein consumed. The experiments of Folin indicate that all the nitrogen arising from the metabolism of tissue protein is represented in the urine by the creatin and uric acid, and that the urea represents the nitrogen of the food. Folin's theory is supported by observations. Liebig observed in hunted foxes that the creatin was ten times as much as in normal muscle; and Gregor found the creatin in the urine of a man rose from 0·57 to 1·34 grammes per diem after fourteen hours' cycling. Chittenden therefore considers that an allowance of 0·10 to 0·12 gramme of nitrogen, or 0·625 to 0·75 gramme of protein, per kilo of body-weight, is quite adequate for physiological needs, provided a sufficient amount of non-nitrogenous

[1] The calorie value of food consumed is not altered by the care exercised in mastication, but the digestibility is altered thereby. Coefficients of digestibility are dealt with in another chapter.

food is taken to meet the energy requirements of the body; in other words, that it is possible to maintain the body in health and perform hard work on less than half the amount of protein considered to be the standard or normal requirement. In confirmation of this he points to the vegetarians, fruitarians, and various races of people, such as the Indian Brahmins, the Japanese, and others, who enjoy health and vigour on a low protein diet. He further states[1] "that the consumption of proteins by people in general far beyond the requirements of the body to maintain health, strength, vigour, and the weight of the body, constitutes a condition of over-nutrition as serious in its menace to the health and welfare of the human race as many other evils of a more striking character." These are strong words, and they constitute a serious indictment of the investigations of a galaxy of men whose decisions have hitherto been considered to have great authority and weight in the scientific world. Nevertheless, observations by other men than Chittenden give rise to thought, for they establish a new standard for protein. Some of these experiments should be considered. It would be well to compare the nitrogen metabolism of people when (1) fasting, (2) on nitrogen-free diet, (3) on low protein diet, and (4) on ordinary diet. And it should be premised that—

1. Nitrogen equilibrium means an equality between the nitrogen consumed and that excreted in the urine, fæces, and other excreta.

2. If more nitrogen is excreted than ingested, the body-proteins (stored and tissue proteins) are being consumed. Moreover, it is possible under such circumstances, when the fat and carbohydrate are sufficient, for the body to increase in weight owing to an accumulation of fat in the tissues.

3. If less nitrogen is excreted than consumed, "the body is laying on flesh"—that is, there is an increase of the nitrogenous tissues. Under certain circumstances, such as "training," this may occur without any increase of the body-weight, or even when the body is losing weight, owing to the combustion of the fatty moiety of the protein molecule and similar constituents of the non-nitrogenous food.

4. When the nitrogenous metabolism is maintained, the protein elements of the body undergo very little change; under these circumstances the tissue elements are replaced as they become worn out, but they are not increased in weight or bulk.

The examples given in the table on p. 107 show that when no nitrogen is taken for twenty-four hours the amount of nitrogen excreted varies from 7·5 to 12 grammes, the variation probably being due to a difference in the amount of *stored protein* and glycogen in the organs and tissues. But the stored protein and glycogen is all consumed in a few days, and after a period, say, of five days all the nitrogen of the excretions is derived from the disintegration of body-protein—that is, organized or tissue protein. The table shows that the amount of nitrogen excreted by the kidneys from the fifth day of starvation averages about 4·5 grammes per diem.

[1] Discussion at British Medical Association meeting, 1906.

NITROGEN METABOLISM.

The Diet, and Subject of Experiment.	Protein. Grammes.	Fat. Grammes.	Carbohydrate. Grammes.	Alcohol. Grammes.	Duration.	Nitrogen— In Food.	Nitrogen— In Urine.	Nitrogen— In Fæces.	Nitrogen— Gain +. Loss −.	Authority.
					Days.	Grammes.	Grammes.	Grammes.	Grammes.	
(*a*) *Fasting* :										
Jacques, professional faster					5	0·0	12·0	0·0	− 12·0	Paton and
Average					25	0·0	4·5	0·0	− 4·5	Stockman.
Succi ,, ,, ,, ...					10	0·0	10·7		− 10·7	Lucieni.
Cetti ,, ,, ,, ...					10	0·0	11·3	·3	− 11·6	Lehmann,
Breithampton ,, ,, ,, ...					6	0·0	11·3	·1	− 11·4	Zuntz, etc.
Ranke, physiologist					1	0·0	7·8	0·0	− 7·8	Ranke.
Woman, eighth to fifteenth day of fast..					7	0·0	4·3	0·0	− 4·3	Tuczek.
Man, fasting					6	0·0	11·3		− 11·3	Munk.
Insane man, fasting, sixth and eighth days					—	0·0	4·3	0·0	− 4·3	Klemperer.
(*b*) *Nitrogen-free Diet* : Fat, starch, and sugar					—	0·0	9·5	0·0	− 9·5	Voit.
					9	0·0	7·2	·8	− 8·0	Reider.
(*c*) *Low Protein Diet* :										
(1) Bread, butter, and potatoes = Protein 39 to 40 grammes daily					6	7·2	6·4	1·4	− ·6	
					2	7·1	5·4	1·6	+ ·1	Pechsel.
					2	6·1	4·8	1·6	− ·3	
					7	5·4	4·2	1·3	− ·1	
					first	5·3	11·7	1·3	− 7·7	Klemperer.
(2)	33	264	470	—	last	5·3	3·3	1·3	+ ·7	
	29	135	268	54	8	4·7	6·1	1·3	− 2·7	
	43	165	354	43	8	7·0	6·6	1·6	− 1·2	Hirschfield.
	47	166	380	43	1	7·5	6·0	1·4	+ ·1	
	64	36	214	20	6	10·1	6·7	1·6	+ 1·8	
	65	22	397	—	4	10·3	7·3	2·0	+ 1·0	Eijkmann.
	60	21	399	—	6	9·5	7·3	2·9	− ·7	
(*d*) *Ordinary Diet* :										
	100	100	240	—	—	15·5	14·4	1·1	+ 0·0	Ranke.
	137	117	352	—	—	19·5	17·4	2·1	+ 0·0	Voit.

If we allow a margin of 1 gramme for other modes of excretion—*e.g.*, by the skin and mucous surfaces—we arrive at the conclusion that *the amount of protein which is absolutely essential to prevent the destruction of tissue-proteins is N* $5{\cdot}5 \times 6{\cdot}25 = 34$ *grammes daily, or about* 0·5 *gramme of protein per kilo of body-weight. This amount, therefore, may be considered the physiological minimum.* The question remains to be considered, Is it advisable to keep too near the physiological minimum? It was after numerous observations that Voit concluded that a man doing ordinary work required 1·7 grammes of protein per kilo of body-weight, or 119 grammes daily, but a variation of 1·4 to 1·7 per kilo was permissible. Since his experiments many others have been made. Klemperer gave considerable attention to the subject—*e.g.*, he made an investigation into the amount of nitrogen actually required by two young men. They took a diet consisting of bread, butter, bouillon, grape-sugar, beer, and cognac. It contained 30 to 33 grammes of protein, but an abundance of fat and carbohydrate. Both subjects consumed the diet for eight days. At first they lost a considerable amount of nitrogen (*stored protein*), but this became smaller, and during the last three days there was a slight retention of nitrogen, showing that the amount consumed was quite sufficient for the needs of their organism, which used a considerable amount of fat and carbohydrate in place of protein. He therefore arrived at the conclusion that strong and healthy persons can maintain their nitrogen metabolism in equilibrium on a diet containing 30 to 40 grammes of protein daily, providing the assimilation of fat and carbohydrate is assisted by the consumption of alcohol. *But he does not advocate the idea that healthy individuals should abandon the ordinary standard of diet.* He believes that Voit's standard represents the amount most suited to the needs of a healthy individual doing ordinary work. The case is different in a diseased person; the object then is not to maintain a high protein level, which is only possible when the excretion of nitrogen is large, but rather to help the organism to form new protein; and the latter only takes place when the excretion of nitrogen is small.[1]

Sivén's experiments showed that a nitrogen metabolism could be maintained in equilibrium with a daily consumption of about 0·5 gramme of protein and 41 calories per kilo, or 28 to 30 grammes of protein and a total of 2,444 calories daily.

Hirschfield found the nitrogenous equilibrium maintained with 47 grammes of protein daily, or 0·63 gramme per kilo and 47 calories per kilo.

Pechsel undertook to determine the amount of protein necessary for his own body; he weighed 169 pounds (76 kilos). He considered Rubner's work in nutrition of especial value, and accepted his data—viz.: 100 grammes of fat = 240 grammes of starch = 249 grammes of sugar = 770 grammes of fresh muscle flesh free from fat, and that the nutrients could be substituted for one another

[1] *Zeit. Klin. Med.*, 1889, xvi. 550.

in those proportions. There was, however, this limitation: some protein was necessary to repair the waste of nitrogenous tissue which is continually going on, and to make up for the loss of portions of the epidermis, hair, nails, epithelial cells, etc. Pechsel's investigations were undertaken, under the direction of Von Noorden, to ascertain the amount of protein necessary for himself. He consumed a diet consisting of bread, rice, potatoes, butter, sugar, tea, etc., *but no meat.* First of all his dietary contained 39 or 40 grammes of protein and yielded 3,640 calories. Nitrogenous equilibrium was reached on the fifth day—that is, the protein was enough to meet the needs of the body, and the organism was sufficiently supplied with fat and carbohydrate. He next reduced the protein to 32 grammes daily, the calorie value of the food being 3,600; but the organism continued to lose nitrogen—that is, 32 grammes of protein daily was less than the smallest quantity needed by a person of his weight to maintain nitrogenous equilibrium. He concluded, however, that Voit's standard for protein is far above the amount actually needed, provided the organism is well supplied with fat and carbohydrate.

THE NITROGEN REQUIRED FOR MAINTENANCE.

Investigator.	Body-Weight.	Calories per Kilo.	Protein per Kilo.	Nitrogen in Food.	Protein in Food.
	Kilos.		Grammes.	Grammes.	Grammes.
Chittenden's physiological minimum	*70*	*varies with work*	*·50*	*5·50*	*34*
Voit's Standard	**70**	**40**	**1·70**	**19·10**	**119**
Maurel's standard	70	—	1·50	16·83	105
Pechsel	77	46	·50	6·30	40
Klemperer (a)	64	28	·52	5·30	33
Klemperer (b)	65·5	27	·50	5·30	33
Hirschfield	73	47	·63	7·44	46
Sivén	59	41	·48	4·53	28

It is undoubted that individuals can live for some time with no nitrogenous food, and with no food at all; but such experiments are of no physiological value beyond assisting to determine, from the metabolism of nitrogen on a nitrogen-free diet or during starvation, the amount of protein needed daily to prevent the disintegration of the bodily tissues. But the observations of Chittenden, Hirschfield, Klemperer, Pechsel, Paton, and others, clearly demonstrate that it is possible to maintain life, keep the body in nitrogen equilibrium, and do a certain amount of work, on a diet having the standard calorie value, but containing a very much smaller amount of protein than is given in the standard dietaries. If there be added, to the 34 grammes of protein established as the physiological minimum necessary to prevent tissue destruction, about 10 or 15 grammes of protein, making a total of 44 to 50 grammes of protein daily, it is argued that there will be an ample provision

to maintain the body in health and vigour, and that anything above that amount will immediately be broken down into a fatty moiety and a urea moiety, the fatty moiety being oxidized to yield heat or stored up in the adipose tissues, and the urea moiety at once turned out by the body in the form of urea.

It should next be inquired how far the need for protein food is influenced by work. It is clearly possible for protein food alone to supply all the energy required by the body, as well as to maintain the body in nutritive and nitrogenous equilibrium. But whether it is necessary or even advantageous for the body to derive a large part of its energy from protein food is another matter. There are people who perforce live upon meat, game, or fish, almost exclusively during six or nine months of the year. In such cases the energy of the body is derived from the fatty moiety of the protein molecule, or from the carbohydrate complex which exists in many proteins. But what we require to know is whether work increases the bodily demand for protein food. Pflüger advanced the theory that protein is the source of all muscular energy. Against the theory is the fact that no evidence has been adduced which clearly shows that there is any change in the condition of the muscle proteins when the muscle contracts. Hermann's theory of muscular contraction assumes that there is a change in the muscular proteins similar to that which occurs in rigor mortis. But nobody has actually observed the formation of a clot of myosin during the contraction of muscle. We have, however, the evidence afforded by the excretion of nitrogen; for it may safely be asserted that, if protein be the source of muscular energy, the exercise of the muscles will materially increase the excretion of nitrogenous waste products. It may be stated at once that this is far from being the case. Krümmacher made observations which he believed supported Pflüger's theory. For fourteen days he took daily, a regular diet containing protein 102·4, fat 43·3, and carbohydrate 230, grammes, and did a certain amount of muscular work; his nitrogen balance during periods of rest and work was as follows:

Comparison of Nitrogen Excretion during Rest and Work.

Condition.	Days.	Nitrogen in Food.	Nitrogen in Fæces.	Nitrogen in Urine.	Loss.
		Grammes.	Grammes.	Grammes.	Grammes.
Rest	3	15·9	1·0	16·1	1·2
Work	3	15·9	1·4	16·9	2·4
Rest	2	15·9	·8	15·3	·2
Work	4	15·9	1·1	17·0	2·2
Rest	2	15·9	1·2	15·3	1·6

The work consisted of the ascent of mountains. These and later observations made by him led to the conclusion that *the cleavage of protein is increased by muscular work, but the cleavage is less in proportion as the supply of non-protein to protein food increases,*

and is not directly connected with the amount of work performed. If it were possible, he says, during a period of work to supply the muscle cells continuously with a sufficient amount of nitrogen-free energy-producing material, there would be no increase in the quantity of protein broken down.

Jones investigated the case of Schmehl, who walked 500 miles in six days, or an average of 83⅓ miles a day. During this period his food consisted of beef-steak, eggs, beef-tea, champagne, and aerated waters. The observer found that the severe exertion caused an increased excretion of nitrogen, phosphoric acid, and sulphuric acid. On the first day of the walk the urea amounted to 63 grammes, on the last day to 39 grammes, so that the excretion gradually diminished during the experiment. It should be observed that the diet influences the amount of urea excreted. A man in a state of equilibrium and on an ordinary mixed diet excretes daily from 25 to 40 grammes, or an average of 33 grammes, of urea. When the diet is poor in protein it sinks to 15 or 20 grammes; when it is rich in protein it may rise to 90 or 100 grammes per diem.

Dunlop, Paton, Stockmann, and Macadam[1], found that there is an increase in the total nitrogen of the urine after severe exertion, chiefly as urea, creatinin, and preformed ammonia; there is also an increase of sulphates and phosphates, but much sweating diminishes the water, chlorides, and sodium, of the urine. If the subject is in poor condition, there is a rise in the excretion of uric acid, creatinin and other nitrogenous extractives, and phosphoric acid. Increased work leads to increased katabolism of muscle protein in such cases; this is supported by the fact that uric acid, nitrogenous extractives, and phosphoric acid, are not increased by work in well-fed healthy subjects.

An investigation was carried out by Atwater and Sherman upon Miller, who succeeded in riding 2,007 miles in six days without showing signs of physical or mental weakness at the end. Miller was a short man, twenty-four years old; the fuel value of his food was 50 per cent. above that of standard dietaries, and contained from 169 to 211 grammes of protein daily. Estimates were made of the food consumed; the urine and fæces were analyzed, and showed that *the protein metabolized in his body was more than that in his food.*

An investigation made on Weston the pedestrian showed that when he took enough protein to keep up his nitrogenous equilibrium he consumed more protein per diem than Miller. Flint[2] and Pavy[3] arrived at different results in this case; but Flint concluded from it that severe muscular exertion increases the excretion of nitrogen considerably.

The amount of nitrogen excreted by men during and after exertion depends to a considerable extent upon the "condition" of the

[1] Abstracts, *Jour. Chem. Soc.*, 1896, p. 570.
[2] *Jour. Anat. and Physiol.*, xii. 91.
[3] *Lancet*, 1876 (several papers).

body. A body in good condition contains an unknown quantity of *stored protein*, which has not become organized into muscular tissue, and is readily available as a source of energy. It appears therefore that, in order to ascertain the amount of nitrogen excreted as the result of muscular exertion, the stored protein ought to be got rid of. In the case of North,[1] who experimented upon himself, an attempt was made to do this. He abstained from food for thirty-six hours before the commencement of his observations. He then took food of which the exact chemical composition had been ascertained, and his urine and fæces were analyzed. For four days he followed his ordinary occupation, and the fifth day he walked thirty-two miles and carried $27\frac{3}{4}$ pounds, and on the succeeding four days he followed his ordinary occupation. The results were as follows: The nitrogen excreted during his ordinary occupation was 15·2 grammes per day, after thirty-two miles' walk 17·95 grammes, or an increase of 2·73 grammes, equivalent to about 18 grammes of protein daily; the excretion of phosphoric acid was increased from 3·59 to 4·19 grammes daily, and the sulphuric acid from 2·74 to 2·97 grammes. The analysis showed that the sulphuric acid in the food was insignificant; therefore that in the urine was derived from the metabolism of tissue protein; and it was increased in proportion to the amount of work done. The increase of phosphoric acid was not great, and might be considered within the limits of experimental error but for the fact that the amount of phosphorus in myosin is very small, and according to Kühne is nil. By means of repeated analyses Kolpakcha found that in meat the $P_2O_5 : N :: 1 : 7{\cdot}3$; in white of eggs $P_2O_5 : N :: 1 : 47{\cdot}6$; gelatin contains no phosphorus. With these facts he was able to determine the amount of tissue-protein or stored protein which was broken down. During a period of fasting the stored protein is first broken down, and it is not until it is exhausted that the organism reaches a condition when tissue-protein is used; and it may be assumed that tissue-protein alone is being broken down when the ratio in the urine of $P_2O_5 : N :: 1 : 3{\cdot}9$ or $4{\cdot}1$. In animals living entirely upon flesh the ratio in the urine of $P_2O_5 : N :: 1 : 7{\cdot}3$, which is about the same as in meat. In North's experiment, having used his stored protein, the $P_2O_5 : N :: 1 : 4{\cdot}3$, which closely approximates to Kolpakcha's estimate for tissue-protein; and the amount of nitrogen excreted daily was increased 15·5 per cent. Muscular contraction therefore increases the total output of nitrogen 15 per cent. when the body contains no stored proteins. But when the body is in good condition—that is, containing a store of circulating protein in the organs of the body—the increase of urea is larger, because such proteins are consumed as a source of energy, but the muscle fibres are not broken down in a greater proportion by the work done by the body.

Paton[2] made further observations on the effects of muscular

1 *Jour. Physiol.*, i. 171, and Proc. Roy. Soc., xxxix. 443.
2 Rep. Lab. Roy. Col. Phys. Edin., iii. 247.

exertion on the excretion of nitrogen. The total amount of work performed was estimated to be 37,366 kilogramme-metres. The excretion of nitrogen was increased during and after the performance of work; and the increased metabolism of protein, indicated by the excretion of nitrogen, accounted for 35 per cent. of the work done. It was evident, therefore, that in these experiments one-third of the energy expended in work was derived from the metabolism of protein, and two-thirds from non-nitrogenous matter, which disproves Pflüger's theory of the source of muscular energy.

Finally, the table[1] on pp. 114 and 115, from the excellent reports of Atwater and his co-workers, will throw light upon the subject. Each experiment was made upon the body of the subject while in the respiratory calorimeter. The report shows the amount of food digested—that is, the total sum of the food available for building tissue and yielding energy. It also shows the available energy of the digested food—that is, the total heat of combustion *minus* the heat of combustion of the unoxidized materials in the fæces and urine—and the gain or loss of protein or fat to the body.

The figures of the table show the average daily amount of available protein and energy supplied by the food, and the amounts actually used by the body when the subject was in a condition of rest—*i.e.*, during a *minimum* of exercise—and also when he was engaged in decidedly active muscular work. The observers remark that there is no doubt that in many cases the body can be kept in nitrogen and carbon equilibrium with smaller amounts of nitrogen and energy than those actually used by any of the men in these experiments; but it is equally certain that in some cases the requirements are much larger. The tentative standards for a daily diet proposed by a number of investigators have served a useful purpose, but they will have to be modified as the fundamental data become more exact and numerous. One principle in dietetics which has not received adequate recognition may be expressed by saying that *the standard varies not only with the condition of activity, but also with the nutritive plane at which the body is to be maintained.* Out of this arises an essential question: "What level of nutrition is most advantageous?" The answer to this question is not an easy one. It must be sought in metabolism experiments and dietary studies, it is true; but it must also be sought in broader observations regarding bodily and mental efficiency, general health, strength, and welfare.

It is possible to answer this question with regard to protein. The physiological minimum for the requirement of protein is 34 grammes per diem; and it has been shown that with an ordinary diet of Voit's standard muscular exertion increases the metabolism of nitrogen 1·1 to 18 per cent., with an average of 15 per cent. From this point of view, therefore, an allowance of 10 to 15 grammes of protein for work to be performed would be sufficient, bringing the

[1] Bulletin 109, Experimental Station, U.S. Department of Agriculture, pp. 129, 130.

INFLUENCE OF WORK ON THE FOOD REQUIRED.

Character and Duration of the Experiment.	Nitrogen.	Carbon.	Energy.	Protein (N × 6·25).	Fat.
(a) Rest Experiments.	Grammes.	Grammes.	Calories.	Grammes.	Grammes.
E. O.: Eleven experiments, average of 37 days—					
In digested food	17·7	231·5	2,459	111	—
In material oxidized	18·5	218·6	2,297	116	—
Gain (+) or loss (−) to the body	−·8	+12·9	—	−5	+20
O. F. T.: One experiment, average of 5 days—					
In digested food	14·4	216·5	2,442	90	—
In material oxidized	13·7	219·9	2,505	86	—
Gain or loss to the body	+·7	−3·4	—	+4	−7
A. W. S.: Three experiments, average of 9 days—					
In digested food	14·7	214·3	2,344	92	—
In material oxidized	13·7	229·1	2,293	86	—
Gain or loss to the body	+1·0	−14·8	—	+6	−24
J. F. S.: Three experiments, average of 9 days—					
In digested food	15·4	228·7	2,381	96	—
In material oxidized	15·7	207·8	2,117	98	—
Gain or loss to the body	·3	+20·9	—	−2	+29

Total: Eighteen experiments, average of 60 days' rest—					
In digested food	16·6	227·3	2,428	104	—
In material oxidized	16·9	218·7	2,285	106	—
Gain or loss to the body	− ·3	+ 8·6	—	− 2	+ 13
(b) Work Experiments.					
E. O.: Two experiments, average of 8 days—					
In food digested	17·6	326·2	3,462	110	—
In material oxidized	17·3	358·9	3,865	108	—
Gain or loss to the body	+ ·3	− 32·7	—	+ 2	− 43
A. W. S.: One experiment, average of 3 days—					
In food digested	14·8	223·6	2,505	92	—
In material oxidized	14·1	371·5	4,225	88	—
Gain or loss to the body	+ ·7	− 147·9	—	+ 4	− 196
J. F. S.: Four experiments, average of 12 days—					
In food digested	15·0	306·4	3,251	94	—
In material oxidized	16·0	330·4	3,547	100	—
Gain or loss to the body	− 1·0	− 24·0	—	− 6	− 27
Total: Seven experiments, 23 working days' average—					
In food digested	15·9	302·5	3,227	99	—
In material oxidized	16·2	345·7	3,759	101	—
Gain or loss to the body	− ·3	− 43·2	—	− 2	− 55

total allowance for maintenance and work up to 44 or 50 grammes of protein daily. We are therefore bound to admit that Chittenden has proved by laboratory experiments that it is possible to maintain life, to prevent the tissues from destruction, and do a certain amount of work, upon an allowance of 50 to 57 grammes of protein—that is, one-half the amount stated in standard diets—providing sufficient carbohydrates and fats are given to meet the expenditure of energy.

Such a small allowance of protein is not desirable. It has not only been proved that half the standard allowance of protein will amply meet the demands of the body for nitrogen, but it has also been shown that anything more than the amount necessary for the formation and repair of muscular tissues is rapidly disintegrated and the urea moiety thrown out of the body; and it is claimed further that the additional amount which is usually consumed is harmful to the organism by throwing extra work upon the kidneys to excrete it, and that it may cause disease of those organs, and, in turn, gout, migraine, and kindred ailments. That an excess of nitrogen may be speedily eliminated is demonstrated by the fact that the amount of nitrogen metabolized is in proportion to the amount consumed. It has already been shown that the amount of urea excreted with an ordinary mixed diet varies from 33 to 37 grammes per diem; but with extra protein the excretion of urea may rise to 50, 60, or even 100, grammes per diem. When no protein is consumed for several days the excretion of urea sinks to about 9 grammes, and with a diet poor in protein to 15 or 20 grammes. The excretion of urea is a function of the kidneys, and it has not been proved that it is injurious for the kidneys to excrete the quantities named above; it may, however, be granted that if the function of the kidneys is defective there will be a retention of urea or other nitrogenous waste products in the body, and the organism will suffer accordingly. In certain regions of the earth people live for many months upon flesh, fish, or fowl, and do not appear to suffer more than Europeans who live on a mixed diet. Carnivora live entirely on flesh, but there is no evidence that disease of the kidneys is produced by the exercise of the function of elimination. Experiments upon animals have shown their need for protein food. Moreover, it has been demonstrated that when the amount of protein in their food sinks below the normal level, even when the calorie value of the food is maintained, they soon begin to suffer from digestive disturbances, loss of appetite, vomiting, incomplete absorption of the food, and they become apathetic and die in a few months. As an example of such experiments, Munk of Berlin [1] made a series of observations on the effects of a *low protein diet* with an abundance of energy-producing food in dogs. He found that, although the food was sufficient to supply 1·6 grammes of protein per kilo of body-weight and an abundance of fat and carbohydrates, all the animals became weak,

[1] Virchow's *Archiv*, cxxxii. 96-102.

and the low protein diet sometimes ended in death. The ration poor in protein caused disturbances of the organism; assimilation became poorer, the assimilation of fat being the most disturbed, that of protein less, and that of carbohydrates being the least disturbed of all. It might be thought that the failure of assimilation was due to defective secretion of the digestive juices, but there was no evidence of this. At any rate, the animals did not recover their nitrogenous and nutritional equilibrium until their ration included 2·9 grammes of protein per kilo of body-weight, the fuel value remaining the same.

If the animals kept on a low protein diet for some time are given skim milk, beans, or other nitrogenous food, a distinct improvement in their condition occurs, if the former experiment has not been continued too long. Bacon from pigs fed on a low protein diet is of a poor quality. The milk of cows fed on a deficiency of protein is poor in fat; the cattle become thin, their coats harsh, and they generally look ill-fed. The absolute and relative amount of protein in the milk is not proportional to the protein in the food, but the quantity of fat in the milk is proportional to the protein in the food.

These experiments upon the lower animals confirm the observations on mankind—viz., that, although it is possible for individuals to live and maintain their health, and work for months together, upon a low protein diet, a continuance of a low protein diet for a long period is harmful, vitality is weakened, immunity to disease is lessened, the body has less activity and endurance; and, moreover, it does not appear to be proved that such a diet is advantageous to the individual.

Muscular work involves the expenditure of energy, and to meet an increased demand for energy more fuel must be consumed. It has been shown that, for the supply of energy, protein, fat, and carbohydrate, can replace one another in a definite proportion. It has likewise been shown that the increased excretion of nitrogen during and after the performance of work is not in proportion to the work done, and, in fact, the energy spent in the performance of work is chiefly derived from non-nitrogenous food. It appears therefore that, when extra work has to be performed, it is sufficient to increase the allowance of fat and carbohydrate alone. But this point cannot be regarded as settled beyond dispute; and it has been the custom for ages past to increase the total food, protein included, in proportion to the extra work to be done. As regards endurance, it is generally accepted as a fact that men who eat plenty of meat are more powerful and have greater staying power or endurance than those who consume little meat. The experience of ages may be called in support of this fact. Animals which consume the most protein are the most energetic. The lion or tiger is more fierce than the bear or deer. Horses fed on beans or oats have more spirit and endurance than those fed on hay or grass, and those fed on good hay (*i.e.*, containing more seeds) than

those fed on poor hay. It is true that feats of endurance can be performed on a vegetarian diet; but this is not necessarily deficient in protein. It may be reasonably asked, Does it matter whether the protein is taken in the form of animal or vegetable food? All proteins consist of amino-acids; they originate in the vegetable kingdom, and many of the amino-acids of animal proteins are precisely the same as those in vegetable proteins; and therefore it would appear *a priori* that there can be little difference in their value upon the organism. But it is remarkable how deficient in flavouring agents are the most valuable protein foods of the vegetable kingdom, and how the existence of these bodies in meat, fowl, and fish, adds to their palatability. It is undoubted that some of these bodies (*meat bases*), especially creatin, act as stimulants to nervous and muscular activity; and herein probably exists one of the great differences between animal and vegetable protein foods. The supposition that the association of unorganized amino-acids with organized proteins renders them of greater value to the body seems to be borne out by experience. Potatoes, for instance, contain a comparatively large proportion of amino-acids (*e.g.*, asparagin) to the organized protein; bread, on the other hand, contains a much smaller amount of free amino-acids. It has been shown that asparagin is a good protein-sparer. That it is a stimulant to cell activity is readily shown by comparing two samples of yeast, one of which is used alone, and the other mixed with a solution of asparagin. It may be from this association that the supposed superiority of potato-protein over bread-protein arises. Rubner, at the International Congress of Hygiene in Berlin, 1907, stated that all forms of protein are not of equal value: 37 grammes of protein of potato is equal to 81 grammes of protein of bread, but meat-protein is superior to either of them.

In concluding this subject one has to inquire—

1. Is there sufficient evidence to show that the muscle can work as efficiently when the lymph surrounding its fibres is practically free from the products of protein digestion and assimilation as when some of its oxidizable particles are derived from protein?

2. Is the evidence derived from laboratory experiments conclusive as to the desirability of reducing the consumption of protein?

3. Is there any conclusive evidence that the consumption of the ordinary amount of protein is injurious to the organism?

The evidence that the amount of protein prescribed by the standard diets is injurious to the organism is not conclusive. On the other hand, there is ample evidence of the bad effects of a long-continued diet of low protein value among the poor who are unable to purchase meat, fish, eggs, and milk, in amounts to supply something near the standard diets. Rubner agrees that from the laboratory standpoint an average consumption of 57 grammes of protein daily would suffice to maintain an adult weighing 70 kilos in nutritive equilibrium and working capacity. But he considers a distinction should be made between the results of laboratory

experiments and rules applicable to the masses of mankind; he concludes that a working man requires an average of 131 grammes of protein, 118 grammes being the *minimum*.

Cohnheim considers Chittenden's experiments do not prove that men eat too much protein; they only prove that they can live for a time upon a smaller amount of protein than usual. He considers that most men could not continue to live upon 50 or 60 grammes of protein and keep in good health. He agrees with Caspari and Loewy that a healthy full-grown man requires at least 80 grammes of protein daily; and that is a considerable reduction from the standard diet. Folin says that as Chittenden's experiments show what is the *protein minimum*, so the so-called "dietary standards" show that the customary or average protein consumption among the most successful nations represents the necessary amount, or *optimum*, of protein consumption; but it seemed to him that the *protein optimum* lay somewhere between these two points. Hutchison accepts Chittenden's results as showing what men can live upon; but he believes there would be danger in their general application; an excess of protein may make for greater immunity to disease. In deciding the question of protein requirement, he compares the food of an adult with that of a nursing infant. An infant of six months consumes milk containing 14 grammes of protein and 578 calories daily; the average energy value of the adult is 3,000 calories, and in the same proportion the standard of protein for the latter should be 74 grammes, the growth in the child being set off against wear and tear in the adult. He says, however, it should be borne in mind that a diet rich in protein increases the power of resistance to infectious diseases, especially tuberculosis, and there may be a danger in having no margin of circulating protein to draw upon. The *protein optimum* may vary in different individuals and under different circumstances, but it is probable that the amount of protein requisite for efficient health is somewhat below the standards hitherto accepted. Halliburton agrees with the results of Chittenden's experiments in metabolism, but considers there is a danger in living too near the *minimum* of the poor, who *nolens volens* have to live on a diet very much like Chittenden's. It is necessary to bear in mind the double part played by protein in metabolism—viz., as a source of energy and a repairer of tissues. In performing the former function the nitrogenous portion is rapidly got rid of as urea. But as a flesh-former it is possible that certain members of the amino-acid group in the protein molecule might be especially necessary for protein synthesis in the body, and it is for these bodies, occurring in small amount, that a larger protein intake is necessary than the apparent minimum.

Haldane considers the basis of Atwater's standards for the energy value of food to be absolutely sound, and the records of cases in which men were placed on a restricted diet showed not only that they lost weight, but the working capacity and resistance to epidemic

and other diseases was greatly diminished. He emphasizes strongly the diminished resistance to infection. This factor is of enormous practical importance when the food-supply of large numbers of persons becomes for any reason restricted. With regard to protein food in particular, he considers the evidence that half the usual amount consumed by Europeans would suffice is not clear, and the experiments of Chittenden on this point do not possess much weight. Alexander Haig found that his patients could not go for long periods on less than 90 or 95 grammes of protein daily without breaking down; some did not break down for eighteen months, but they became weak and anæmic.

Kellog subscribes to the doctrine that no protein is stored in the system, and considers that all protein above 60 or 70 grammes daily is broken down in the alimentary canal by bacteria into toxins such as indol, skatol, phenol, leucin, tyrosin, etc., and cause auto-intoxication.

The conclusion is that, while a *minimum* of protein is essential to the organism, a greater proportion is advantageous by acting as a stimulant to metabolism and as a ready source of energy; that people are better for the consumption of protein in quantities greater than Chittenden's standard, and possess greater resistance to disease, probably because the organism is stimulated to manufacture antibodies. On the other hand, the well-known experience of ages has shown that the poor who live on a low protein diet are the most liable to various diseases. It is difficult to decide on a fixed quantity which should be called the *optimum of protein*; it is probably influenced by the personal equation in each case. It may, however, be urged that during the period of growth and up to middle age the *optimum for protein* is higher than from middle age onwards. It is impossible to eliminate from the question the factors of race, climate, and custom, and, although it is certain that three meat meals a day are unnecessary, and even undesirable in many cases, it cannot be gainsaid that the meat-eater has greater stamina and energy than the individual whose diet is poor in protein. The question, therefore, of protein rests upon whether it is desirable that the stored proteins of the body shall be maintained at a high level or at a low level. Hence it must be stated that a high level is better for some people and a lower level for others. It is well known than the metabolic processes are feebler in some persons than others. In early life the metabolic processes are very active, the eliminatory organs are healthy, and therefore any amount of protein above the physiological requirement which may be consumed is speedily utilized, being oxidized or stored in the tissues as muscle or fat. So long as the alimentary organs are capable of digesting and assimilating protein, and the liver and kidneys are capable of transforming the nitrogenous portion to urea and excreting it, protein food is not injurious to the body. But when middle life is reached the metabolic processes become less active, and protein, if taken in quantities above the physiological

requirement, tends to an accumulation of fat in the tissues; and the urea moiety is not so easily excreted because the liver is less efficient and the excretory power of the kidneys may fail. It is then that care needs to be exercised, that the consumption of protein needs to be kept down, that the *optimum* sinks to a lower level than in youth and early adult life. The *optimum* of former days may now become an excess. The power of digestion may also fail, especially if, from the consumption of alcohol or other causes, the mucosa of the alimentary canal is in a condition of chronic catarrh, and bacteria may flourish and produce toxins by the decomposition of protein, the absorption of which sets up arterio-sclerosis, chronic nephritis, chronic disease of the liver, and other diseases which disturb the normal course of protein metabolism.

The Amount of Fat and Carbohydrate required.—These points cannot very well be separated from the former, and have already received consideration when dealing with the question of energy, and again when discussing the amount of protein required. Benedict, in his refutation of Chittenden's advocacy of a diminution of protein, says: "Food should be ingested in just the proper amount to repair the waste of the body; to furnish it with the energy it needs for work and warmth; to maintain it in vigour; and, in the case of immature animals, to provide the proper excess for normal growth, in order to be of the most advantage to the body." He gives the following figures as representing the average of very many dietaries:

Atwater and Benedict's Dietaries.

Subjects.	Fuel Value.	Total Protein.	Digestible Protein.
	Calories.	Grammes.	Grammes.
Men with light muscular work: professional men, business men, clerks, etc.	2,700	100	92
People with ordinary muscular work: carpenters, mechanics, farmers, etc.	3,300	115	105
Men with active muscular work: athletes, lumbermen, etc.	5,500	175	160

The amount of carbohydrate and fat required will depend to some extent upon the quantity of protein consumed. As we have already seen, Voit's standard for protein is 1·7, Maurel's 1·5, Chittenden's 0·7 to 0·9, gramme per kilo of body-weight; and therefore the amount of protein varies from 118 grammes allowed by Voit down to 57 grammes by Chittenden, yielding from 484 to 234 calories, or units of heat. Benedict, however, remarks that, "dietary studies all over the world show that in communities where productive power, enterprise, and civilization, are at their highest, man has instinctively and independently selected liberal rather than small quantities of protein." Assuming, then, that 450 to

480 calories are derived from protein, there remain 2,000 calories or more to be derived from non-nitrogenous sources.

It is almost impossible for persons in ordinary health and under ordinary circumstances to live continuously without carbohydrate. Persons can live, of course, upon animal food for months together. But it is usually found, when the diet has been deficient in carbohydrate for a long time, that a condition of acetonæmia occurs, and acetone and diacetic acid are excreted in the urine. This arises from the call which Nature makes upon the fatty tissues to supply the energy for working the machinery and yielding heat. Under certain circumstances, such as living an out-of-door life combined with great activity, the metabolism of fat is complete, whatever demand is made upon the organism. But if the average European, living the ordinary life of his country, consumes only animal food, the metabolism of fat may be incomplete owing to deficient oxidation. Hence the bodies arising from incomplete oxidation of fat produce acetonæmia, acetonuria, etc. Such a condition occurs in many infants who are fed with milk diet which is defective in carbohydrate, and in diabetics kept upon a strict dietary for a length of time. The latter class of people teach us how *little* carbohydrate the adult organism can do with. The amount of carbohydrate which will prevent acetonuria varies in individual cases, but it has been found that as little as 70 grammes per diem is sufficient in the majority of cases. It may therefore be taken that *the minimum amount of carbohydrate* which may safely be consumed by a person of average weight—*i.e.*, 154 pounds (70 kilos)—is 70 grammes, or 1 gramme per kilo of body-weight, whereas the amount prescribed in the standard dietaries varies from 4 to 6 grammes per kilo for a man doing a moderate amount of work. For various reasons the amount given in standard dietaries may be considered to be the *optimum*, but the proportion required must vary as the proportion of fat consumed and the work done. Whatever deficiency may occur in the calorific value of the food owing to a deprivation of a part of the carbohydrate must be made good by fat, or protein and fat. It is considered that the maximum for protein is 190 grammes. It has also been shown that an excess of fat will not be tolerated for a very long time, that its metabolism is apt to become defective, and even its assimilation may be defective. When considering the digestibility of foods, it was shown that if a very large amount of fat is consumed a larger percentage will reappear in the fæces. But as much as 240 grammes (8 ounces) of butter have been consumed with a reappearance of only 2·7 per cent. in the fæces; whereas the consumption of 100 to 145 grammes of bacon or other fat meat was followed by the reappearance of 13 to 17 per cent. in the fæces. Respecting the amount of fat which can be completely oxidized in the body in a state of health we have little available information. But it is evident that when hard work is being performed a large amount can be disposed of, as much as 6 to 9 ounces of butter

(150 to 250 grammes) having been taken and apparently utilized. This is an advantage in some respects, as the heat-value of fat is two and a quarter times as much as that of carbohydrate or protein, and therefore a considerable number of calories can be taken in the form of butter, dripping, bacon, or fat meat.

As to whether fat and carbohydrate are both necessary, a discussion on other matters is involved. As a rule children do not thrive whose food is deficient in fat; adults are prone to tuberculosis and nervous diseases when the fat in their body is deficient. Fat, however, may actually be formed in the body from the fatty-moiety of proteins or from carbohydrates, and therefore the surplus fat of the body may be fat merely stored up from the food. Instances of the formation of fat from protein occur in carnivorous animals, in the formation of adipocere, in the ripening of cheese, and in the secretion of milk. The formation of fat from carbohydrates was first investigated in pigs by Lawes and Gilbert; but Rubner, Meissl, and others, have made observations thereon. One of the most important instances of the origin of fat from carbohydrates occurs in the formation of beeswax. The formation of fat from carbohydrates occurs probably in all animals, although its explanation on chemical grounds is considered difficult. In some experiments upon oxen at the Möckern Experiment Station from 1882 to 1890,[1] it was found that the smallest ration which will maintain a steer in equilibrium must furnish 0·7 kilo of digestible protein and 6·7 kilos of digestible nitrogen-free substance per 1,000 kilos of body-weight daily; that any excess over that amount results in the formation of fat; that it makes no difference whether the excess consists of nitrogenous or non-nitrogenous matter; but the conclusion was arrived at that fat is produced from carbohydrates, and 1 kilo ($2\frac{1}{5}$ pounds) of starch produced an average of 0·2 kilo (7 ounces) of fat. In fact, the observation showed that the amount of fat formed from carbohydrate was seven or eight times as much as that introduced into the body pre-formed or derived from protein. It may therefore be concluded that a considerable proportion of fat accumulated in the human body is derived from carbohydrates.

How is Fat used in the Body ?—Chaveau[2] considers that fats are chiefly transformed into carbohydrates, and this view is supported by observations on hibernating animals, and we cannot otherwise interpret the fixation of oxygen during the winter sleep of such animals with the gradual disappearance of fat and the reconstruction of glycogen and glucose. But there is nothing which warrants the conclusion that this process occurs only in hibernating animals: on the contrary, he considers it to be a *regular* physiological process. The *potential* directly devoted to the physiological work of the muscles is always a carbohydrate, which is borrowed from the reserves of glycogen in the organism, or derived by transformation of fat immediately absorbed in the food or furnished by the fatty

[1] Bulletin 45, p. 405, U.S. Department of Agriculture.
[2] *Compt. Rend.*, 1896, cxxii., 20-22.

reservoirs of the organism. The latter is the source and nature of the potential directly utilized in muscular work by a man in a state of inanition. The *immediate* destination of fat is the maintenance of the *potential* of the organism. If the reserve of carbohydrates is impoverished, as in a state of inanition, the alimentary fats may at once be used; but if otherwise, they go to the reservoirs of adipose tissue, where the fatty principles are stored up for future use, and whence they are drawn as required. The evidence supplied by the respiratory changes shows that fat never directly constitutes the *potential* utilized by the muscles, even in a state of inanition. It is always in the form of a carbohydrate that the energetic potential is supplied to muscular activity. The work of the muscles tends to exhaustion of the reservoirs of glycogen and glucose; but, in spite of abstinence from food, these reservoirs tend to replenish themselves in proportion to their consumption.

Fat versus Carbohydrate as a Source of Muscular Energy.—Calorimetric observations have shown that the caloric value of fat and carbohydrate have a definite ratio $= 2\frac{1}{4} : 1$. But other observations[1] have shown that as sources of muscular energy carbohydrates have a slightly superior value to an isodynamic quantity of fat as a part of a ration for muscular work. While, however, calorie for calorie, the carbohydrates are slightly superior to fats as a source of muscular energy, the difference observed is so small as to be due to personal peculiarities rather than any inherent difference in the capacity of the materials to yield energy for muscular work. The difference, such as it is, probably arises from the chemical composition or molecular constitution of the molecules. The hydrogen in the carbohydrate molecule is already fully oxidized, and therefore only the carbon is available for oxidation. In the fats, on the other hand, neither the carbon nor the hydrogen are fully oxidized, whence arises the superior calorific value of fat over carbohydrates. But fats are not so quickly available for use by the muscles, because they have to be transformed into carbohydrate. On the other hand, carbohydrates are readily available. Starch is quickly transformed into sugar, and sugars into glycogen and glucose. The great value, for instance, of cane-sugar as a source of muscular energy has been shown by many observers. Pettenkofer framed the dictum that good work needs a muscular system developed by the aid of a nitrogenous diet and supplied by a circulation enriched with sugar. The sugar need not be consumed as cane-sugar, but merely as digestible carbohydrate. However, the rapidity with which cane-sugar is assimilated gives it an advantage over starch and other non-saccharine carbohydrates during periods of exhausting labour, and it is much used by men who have heavy work to do, such as harvest-men, lumber-men, athletes, etc. Experiments made by Mosso's ergograph showed that less muscular deterioration occurred in men who worked on a diet containing a large proportion of sugar; that when muscles were fatigued and

[1] Bulletin 136, pp. 183-187, U.S. Department of Agriculture.

incapable of further work, a meal rich in sugar quickly rendered them fit again. Thus, Schumberg found that when muscles had been exhausted by work, sugar restored the power of the tired muscles in thirty-five to forty minutes, so that results obtained by the ergograph were scarcely distinguishable from those obtained before they had become exhausted. These results are in accordance with common usage and experience. When men have extra work to do, they do not as a rule greatly increase the amount of fat in their diet, except in sufficient proportion to aid in the consumption of bread, but the majority of them prefer to increase the carbohydrate.

Carbohydrate and Fat versus Protein as a Source of Muscular Energy.—Muscle itself affords no evidence of an increased metabolism of nitrogen within its elements during exercise, but there is a clear proof of an increased oxidation of non-nitrogenous materials leading to an increased excretion of CO_2, etc. The evidence concerning the excretion of urea during and after exertion is somewhat conflicting. In many observations no marked change could be observed; in others there was a slight decrease of urea excreted on the days when work was done, and a decided increase on the days following work; and in other cases there was a marked increase of urea when severe labour was performed, but the increase was not proportionate to the work done. On an ordinary diet the increase due to work is not more than 9 or 10 per cent. On the other hand, the production of CO_2 is at once and largely increased by muscular labour. The following observations were made in one experiment:

Condition.	Oxygen consumed	CO_2 produced.	Urea excreted.
	Grammes.	Grammes.	Grammes.
Rest, one day	708	911	37·2
Moderate work, one day	954	1,284	37·0

It is obvious, therefore, that a man doing even moderate muscular work needs a larger supply of energy-producing food than a man at rest or following a sedentary occupation; it is also obvious that carbohydrates and fats are the chief source of the energy. It has previously been shown that there is no basis for the assumption that protein is the sole source of muscular energy. The general belief of physiologists is that all the nutrients of food, proteins, fats, and carbohydrates, supply muscular energy in proportion to their calorie value. The carbon metabolism is principally augmented by muscular work, and this suggests that extra food for extra work should consist exclusively of carbon compounds. Atwater,[1] after making very many observations, arrived at these conclusions: (1) That a considerable amount of energy for muscular

[1] Bulletin 136, p. 190, U.S. Department of Agriculture.

work must come from substances other than protein; (2) it is in the highest degree probable that the largest part of the energy comes from carbohydrates and fat; (3) that these observations leave no basis for the assumption that proteins are the sole source of muscular energy; and (4) it is also probable that carbohydrates are more readily and directly available for the supply of the *potential* in the muscles. This consideration points to the conclusion that any increase of energy demanded for work should be supplied by an increase of carbohydrates rather than fat or protein. "But in choosing a diet for muscular labour," Foster[1] says: "We must have in view the condition not only of the muscle, but of the whole organism. The power of doing work depends not on muscle alone, but on the heart, lungs, nervous system, indeed the whole body. Fatigue is more a nervous than a muscular condition, and is, partly at least, due to the accumulation of waste products, and not merely to the exhaustion of available energy. These considerations, therefore, would tend to the conclusion that what is good for the organism in a state of rest is good for it in hard work, and that the diet normal for the former condition is correct for the latter, no change in the ratio or composition being needed, but a total increase in proportion to the work to be done." A man doing a moderate amount of work will eliminate from his body from 250 to 280 grammes of carbon per diem, or during active muscular work 330 to 350 grammes of carbon daily. During the same time he will also eliminate about 15 to 19 grammes of nitrogen. The ratio of carbon to nitrogen in the food therefore should be about 16·6 to 1. Now, the proportion of carbon and nitrogen in protein averages 3·5 to 1. Hence the diet of a person living wholly on protein would be incorrectly balanced: if he consumed just enough protein to supply the nitrogen demanded by the body, the carbon would be deficient; if, on the other hand, he consumed enough to supply the carbon, there would be a great excess of nitrogen. To provide the 250 grammes of carbon would necessitate the consumption of 500 grammes of protein, obtainable from 5 to 6 pounds of beef. This quantity of beef would contain much more nitrogen than was lost by the body during a day's work, and probably more than the kidneys could excrete. A purely protein or lean meat diet, although applicable in certain cases for a short time, is impossible for continued usage; it would not maintain the body in health over a long period, and as a rule the body would waste rapidly (see Obesity). The body requires organic phosphorus and sulphur as well as nitrogen, and their absence renders a carbohydrate or fatty diet equally impossible for more than a few days. Therefore the correct principle for framing dietaries is to keep the quantity of protein at such a level as will replace the quantity of nitrogen lost daily, and to supplement this by non-nitrogenous foods to bring up the dietary to the proper standard required to supply heat and energy. As to whether both fat and carbohydrate are essential involves

[1] "Textbook of Physiology," vol. ii.

other points, such as the comparative digestibility, bulk, and calorie value. It has been shown that some fat in the diet is essential to the continuance of good health. It has also been shown that fat can be formed in the body from carbohydrate; but it should be remembered that all persons do not appear to possess this faculty in an equal degree. As a matter of fact, it has been found that animals thrive best when their carbon is derived from both fat and carbohydrate, thus confirming the experience of ages that the best food either for the worker or non-worker is a mixture of proteins, carbohydrates, and fat. Respecting the quantities of these substances required, Foster[1] says: "To put down a single column of figures as the **normal diet** would be to affect a vain and delusive accuracy." The following diets show how authorities vary:

	Ranke.		Cornet.		Voit.	
	Ounces.	Grammes.	Ounces.	Grammes.	Ounces.	Grammes.
Protein	about $3\frac{1}{2}$	100	$4\frac{1}{4}$	120	$4\frac{1}{2}$	137
Fat	$3\frac{1}{2}$	100	$1\frac{3}{4}$	50	$3\frac{7}{8}$	117
Carbohydrate ..	$8\frac{1}{2}$	240	$17\frac{1}{2}$	500	$12\frac{1}{4}$	352
Salts	$\frac{3}{4}$	25	$1\frac{1}{8}$	30	$1\frac{1}{8}$	30
Calories	—	2,310	—	3,007	—	3,113

If we consider the physiological requirement of protein to be that previously fixed, then it must be allowed that Ranke's diet is in that respect nearer to the normal than Cornet's; and if the cost is of no moment, the substitution of fat for carbohydrate by Ranke is again desirable, and therefore Ranke's diet is more satisfactory than Cornet's. It is true that the calorie value of the former diet is low, having been arranged for a professional man, and would not be sufficient for a man doing hard work. Ranke's diet would allow a moderate consumption of meat; Cornet's diet a large consumption of bread and a moderate consumption of meat. Statistical diets, arranged from the amount of food usually consumed by people, are not scientifically arranged; instinct is not an unerring guide, and the choice of food depends upon other circumstances than the physiological value and composition of the food.

Some examples of food actually used in English families, the army, navy, mercantile marine, workhouses, prisons, etc., will now be given.

Family Dietaries.—The first is the menu of a moderately well-to-do family for one week in February:

SUNDAY.

Breakfast.—Whitings, veal-and-ham pies, rolls, toast, butter, marmalade, coffee.

Dinner.—White soup, jugged hare, potatoes, Brussels sprouts; apple charlotte, custard, lemon-sponge; cheese and biscuits; oranges, apples, nuts.

Tea.—Bread-and-butter, sultana and other cakes.

Supper.—Cold mutton, tomatoes, watercress, bread, butter; milk-jelly; cheese.

[1] "Textbook of Physiology," ii. 834.

MONDAY.

Breakfast.—Bacon and eggs, stewed mushrooms, toast, bread, butter, marmalade, coffee.

Lunch.—Hare soup, jugged hare, cold mutton, potato; stewed prunes and blancmange.

Dinner.—Ox-tail soup, roast beef, batter pudding, potatoes, artichokes, sauce; mince-pies, vanilla cream; cheese, celery, coffee; almonds, raisins, grapes.

TUESDAY.

Breakfast.—Sausages, poached eggs, rolls, toast, butter, marmalade, tea or coffee.

Lunch.—Artichoke soup, cold roast beef, horseradish sauce, baked potatoes; apple tart; cheese, celery.

Dinner.—Codfish, egg-sauce, roast chicken, seakale, potatoes; Chester pudding, fruit salad and cream; cheese and biscuits; nuts, dates, apples.

WEDNESDAY.

Breakfast.—Boiled ham and tongue, scrambled eggs, rolls, bread, butter, marmalade, tea or coffee.

Lunch.—Cold chicken and ham, salad; stewed rhubarb and cream; cheese, bread; fruit.

Dinner.—Clear soup, stuffed veal, potatoes, cabbage; fruit salad, lemon jelly; cheese; dessert.

THURSDAY.

Breakfast.—Oatmeal porridge, white herrings and mustard sauce, sausage rolls, bread, toast, marmalade, coffee.

Lunch.—Pea soup, cold ham and tongue, tomatoes; rice pudding, stewed figs; cheese and celery.

Dinner.—Thick soup, boiled leg of mutton, caper sauce, potatoes, mashed turnips; trifle, stewed figs, custard; cheese, celery; fruit.

FRIDAY.

Breakfast.—Stuffed tomatoes, kidneys and bacon, bread, toast, butter, watercress, golden syrup, tea or coffee.

Lunch.—Halibut, shrimp sauce; tapioca pudding; cheese, watercress.

Dinner.—Tomato soup, duckling, green peas, apple sauce, potatoes; coffee pudding, almond sponge roll; cheese; bananas, oranges.

SATURDAY.

Breakfast.—Pig's head brawn (head cheese), Durham cutlets, fried tomatoes, toast, bread, butter, golden syrup, coffee.

Lunch.—Haricot mutton, potatoes; French pancakes, marmalade tart; cheese.

Dinner.—Mulligatawny soup, scalloped oysters, rabbit stewed in milk, potatoes, haricot beans ; lemon sponge, velvet cream; cheese, celery; dessert.

The entire dietary consumed in the week ending February 18, 1911, by a family of eleven persons, including servants, after allowing 10 per cent. for waste, gave per person an average of 144 grammes (5 ounces) of protein, 99 grammes ($3\frac{1}{2}$ ounces) of fat, and 243 grammes ($8\frac{1}{2}$ ounces) of carbohydrate, or 2,517 calories per day, at a cost of about twelve shillings each per week. In this dietary the protein is high, not because the meat and fish are excessive, but by reason of the eggs, milk, etc., used in the preparation of many of the sweets.

The following is the amount of provisions actually used in a working-class family in the week ending January 21, 1911: Meat, 15 pounds; liver, 1 pound; bacon, 5 pounds; salmon (canned), 2 pounds; codfish, 2 pounds; milk, 20 pints; cheese, ½ pound; butter, 4 pounds; lard, 1 pound; sugar, 8 pounds; bread, 48 pounds; cake, 3 pounds; eggs, 24; flour, 7 pounds; potatoes, 20 pounds; dried peas, 2 pounds; cabbage and Brussels sprouts, 14 pounds; onions, 4 pounds; rolled oats, 2 pounds; apples, 6 pounds; tomatoes 3 pounds; jam, 4 pounds; dried currants (Zante), 1 pound; tea, ¾ pound; cocoa, ¾ pound. This dietary, after allowing 10 per cent. for waste, provides an average of 103 grammes of protein, 97 grammes of fat, and 360 grammes of carbohydrates, per day for each person. But the family consisted of eight persons, and the food consumed daily by them was estimated to contain the following amounts:

Subjects.	Protein.	Fat.	Carbohydrate.
	Grammes.	Grammes.	Grammes.
Three men, each	103	97	360
Two women, each	83	78	288
Girl sixteen, boy thirteen, each	72	102	418
Girl aged nine	60	98	383

According to the mother's statement, the two girls ate 2 pounds of bread each per day, one of the young men and the boy ate from 2 to 3 pounds of bread per day. The average cost was 6s. 5d., or 1·55 dollars, a week per person.

The following is the list of food consumed by another working-class family in the week ending February 25, 1911: 6 pounds of beef, 5 pounds of mutton, 1 pound of steak, 1 pound of stewing beef, 1 pound of beef sausages, 50 eggs, 25 pounds of potatoes, 1 pound of dried peas, 3 pounds of cake, 2 pounds of cheese, 6 pounds of bacon, 3 pounds of codfish, 1 tin of salmon, 3 pounds of lard, 3½ pounds of butter, 56 pounds of bread, 4 pounds of flour, 18 pints of milk, 6 pounds of sugar, 1 pound of rice, 1½ pounds of tomatoes, ½ pound of tea, ½ pound of cocoa, condiments, green vegetables, a little fruit, custard powders, tablets for jelly, etc. The dietary, after allowing 10 per cent. for waste, provided 100 grammes of protein, 111 grammes of fat, and 390 grammes of carbohydrate, per day for each person, at a cost of 6s. 11d. per head per week. The family consisted of five men and two women. The consumption of the food was probably as follows:

Per man: Protein 105, fat 115, carbohydrate 430 grammes.
Per woman: ,, 86, ,, 98, ,, 386 ,,

In an inquiry by the British Board of Trade (1908) into the conditions of life among the working classes, it was found, as was

expected, that the expenditure on food varies with the income. The actual weekly expenditure was ascertained from 1,944 families, and, together with the income, was as follows:

WEEKLY INCOME[1] AND EXPENDITURE ON FOOD OF 1,944 FAMILIES.

	Average Income.	Cost of Food.
	£ s. d.	£ s. d.
Class A	1 1 4½	0 14 4¾
,, B	1 6 11¾	0 17 10¼
,, C	1 11 11¼	1 0 9¼
,, D	1 16 6¼	1 2 3½
,, E	1 12 0½	1 9 8
Total average ..	1 16 10	1 2 6

The average amount of food consumed per week by these families was as follows: Bread, 22 pounds; flour, 10 pounds; potatoes, 17 pounds; butter, 2 pounds; cheese, ¾ pound; bacon, 1½ pounds; meat, 6½ pounds; sugar, 5⅓ pounds; tea, ⅗ pound; eggs, 1 dozen; milk, 10 pints. Coal used, 2 hundredweights. This would provide for a family of persons as follows:

Subjects.	Protein.	Fat.	Carbo-hydrate.
	Grammes.	Grammes.	Grammes.
A man	100	95	450
One youth	71	78	542
,, woman ($\frac{7}{10}$ man)	70	64	315
,, child, six to nine years ($\frac{5}{10}$ man) ..	50	48	225
,, ,, three to five years ($\frac{4}{10}$ man) ..	40	40	180
,, ,, under two years ($\frac{3}{10}$ man) ..	30	30	135

The amount spent on bread, meat, and milk, varied with the income. The average amount spent on meat and fish was 6s. 4¾d., and on milk 1s. 3¼d., per week per family; and the amount of bread and flour consumed averaged 32 pounds, but it varied from 28 to 38 pounds. When the income was below 25s. per week, the expenditure on bread and flour was 21 per cent. of the total; when the income was between 35s. and 40s. per week, the amount spent on bread and flour was 15 per cent. of the total expenditure; while the amount spent on meat and fish increased proportionately. Oatmeal is largely used by the Scotch working classes, but hardly at all by the same classes in England. Foreign and colonial meat is much used by these classes in England, but to a far less extent in Scotland.

A chart issued in 1907 by the York Health and House Reform

[1] One shilling = 12 pence; 50 pence = 1 dollar.

Association gives a dietary for a man, wife, and three children, aged eleven, eight, and five years; the total food cost 12s. 9d. per week, and gave the man a daily allowance of—protein, 128 grammes; fat, 128 grammes; carbohydrate, 457 grammes. The food and the price in 1907 was as follows:

TABLE OF ECONOMICAL FOOD FOR FAMILY OF FIVE PERSONS FOR ONE WEEK.

	s.	d.
5 pounds meat: Liver, 5d.; shin-beef, 6d.; breast of mutton, 4½d.; scrap beef, 4½d.; neck of mutton, 6d.; total	2	2
1 pound tripe	0	6
½ pound bacon, at 7d. ..	0	3½
½ pound cheese, at 6d. ..	0	3
2 pounds 15 ounces meat dripping, at 5d.	1	2½
11 herrings, at 9d. per dozen	0	8½
Bones for soup	0	2
8 quarts skim milk, at 1½d.	1	0
16 pounds flour for bread, at 1s. 2d. per stone	1	6¼
5 pounds pastry flour, at 1s. 6d. per stone	0	6½
2¼ pounds oatmeal, at 2d. ..	0	4½
14 pounds potatoes, at ½d. ..	0	7
1 pound peas, 2½d.; ¾ pound lentils, 2d.; ½ pound barley, 1½d.; ¼ pound rice, ½d. ..	0	6½
3 pounds sugar, at 2d. ..	0	6
1½ pounds treacle, at 2d. ..	0	3
⅜ pound jam, at 4½d. ..	0	1¾
¼ pound figs, at 3d. ..	0	0¾
½ pound dried currants, at 4d.	0	2
3¼ pounds onions, at 1d. ..	0	3¼
2 turnips, 4 carrots	0	2
½ pound tea, 7½d.; ⅜ pound cocoa, 3¾d...	0	11¼
Baking-powder, yeast, and condiments	0	4½
Total	12	9

Considerable economy arises from the consumption of the cheaper joints of meat, home-made bread, and skim milk indicated herein; also by the substitution of dripping for butter and lard. In many dietaries for working-class families economy is practised by the use of foreign meat. It may be stated here that the use of foreign and colonial meat receives the approbation of all men who have considered the dietaries of the poor. Prior to the introduction of these foods, fresh meat was rarely seen on the tables of the poor more than once a week; but the importation of chilled beef and mutton has brought these valuable sources of protein within the reach and purchasing power of nearly everybody. A sufficient supply of proteins can be obtained from an equally economical vegetarian diet; but it appears that the inhabitants of Great Britain as a rule prefer that their diet should contain some animal food, which is more costly. The compilers of the York Chart point out that the cheaper cuts of beef and mutton, *when stewed*, are as nourishing as steaks and chops, which are far more expensive; that *frying* is the most expensive mode of preparing meat; that beef dripping is more appetizing than bad butter; that oatmeal is as nourishing as the fancy breakfast foods, although it requires longer cooking; that peas and beans have an especial value, but are only digestible when they have been soaked and well cooked. After making an investigation into the dietaries of the working classes, Noel Paton and Crawford Dunlop reported as follows:

"Bread forms the basis of all diets. It provides an average of one-third of the total energy and one-third of the total protein consumed. It is a cheap food. For providing energy we find only oatmeal and sugar are cheaper; for providing protein we find only oatmeal and peas are cheaper.

"Sugar is one of the most important foodstuffs of the poor. It is solely an energy provider, but for this purpose it is the cheapest of all.

"Butter, margarine, dripping, and suet, are also cheap as a source of energy. They rank third as a source of energy, only sugar being cheaper.

"Potato is a more expensive food than bread; both as energy and protein provider *it is twice as dear,* but its antiscorbutic properties justifies its use in dietaries.

"Oatmeal costs less than bread as a source of both protein and energy. Peas are cheaper than oatmeal as a protein provider; sugar is cheaper as an energy provider; but the latter contains *no protein.* As a food providing cheap energy and having a good protein value, oatmeal is the best of the entire list.

"Beef is an expensive source of nourishment. Its protein is four times as dear and its energy nine times as dear as that of bread. Ham is cheaper than beef, both as energy and protein provider, and so are sausages and mutton.

"Fresh fish is cheap as protein provider, but dear as energy provider. Smoked fish or dried fish is expensive both as energy and protein provider.

"Cheese is a cheap source of protein and energy.

"Eggs are expensive both as energy and protein providers. Their large use may be attributed to the small amount of trouble required in cooking them.

"Milk is also comparatively expensive. As a source of energy it is five times, and as a source of protein three times, as dear as bread; but it is essential in the diet of small children. . . .

"Without an adequate supply of food, growth and development of the body are impossible, the working capacity of the individual is reduced, and a predisposition to disease is induced. . . . The large use of food which provides energy, but not protein, is one reason why the dietaries of the poor are so badly balanced; they contain but little protein comparatively to their energy. . . . A dietary consisting of tea and bread-and-butter is faulty; it can be improved by the free use of meat and other animal foods, but these are expensive. It can also be improved by the free use of oatmeal and milk, or by peas, beans, or lentils, which add little to the cost, but require much more care in the cooking. A daily diet containing meat need not cost more than sevenpence per person; but when the meat is replaced by peas and beans, or oatmeal and milk, it need not cost more than fourpence."

König also showed that a vegetarian dietary is more economical than mixed diet, and made the following calculation: 100 grammes

of protein from the **animal** kingdom cost 65 pence, and 100 grammes of animal fat 20 pence; from the **vegetable** kingdom, 100 grammes of protein cost 15 pence, 100 grammes of fat 4½ pence, and 100 grammes of carbohydrate 2½ pence. A consideration of the vegetarian dietary will be given in another chapter.

The Food of Armies.—The following are examples of the rations of soldiers in time of peace and war:

DAILY RATION OF THE ENGLISH SOLDIER.

Peace.	Ounces.
Meat, fish, bacon, or liver	12
Bread	16
Vegetables	4
Potatoes	1·2
Milk	5
Sugar	2
Butter	1
Peas or beans, in lieu of vegetables	1½
Lime-juice	1
Salt, ½; tea, ⅙; or coffee,	½

War.	Ounces
Meat, fresh	16 or 20
Or preserved	20
Bread	20
Or biscuits	16
Vegetables, fresh	16
Or compressed	1
Peas or beans in lieu of vegetables	3
Sugar	3
Cheese	2 to 4
Tea, ½; coffee or cocoa	½
Pickles, occasionally.	
Rum, when necessary	2½

DAILY RATION OF THE FRENCH SOLDIER.

Peace.	Ounces.
Meat	10½
Bread	26¼
Or biscuits	21
Vegetables, fresh	3½
Butter	2⅛

Other articles are paid for by men out of their allowance. Laveran estimates that the ordinary peace ration contains 124 grammes protein and 764 grammes carbohydrate.

War.	Ounces.
Meat	14½
Bread	26¼
Or biscuits	21
Vegetables, compressed	1
Butter	1
Rice	2¼
Sugar	¾
Soup, condensed	¼

DAILY RATION OF THE GERMAN SOLDIER.

Peace.	Garrison. Ounces.	Field. Ounces.
Meat	5½	17½
Or bacon	4½	6
Bread	26½	35½
Or potatoes	53	71[1]
Oatmeal	4¼	6½
Rice	3⅙	—
Coffee	—	1½
Butter		1¼

War.	Ounces
Meat	13¼
Or sausage	8¾
Bread	26½
Or potatoes	52
Vegetables	6
Rice or ground barley	4½
Coffee	1
Brandy	3½
Or wine	17½
Or beer	35

[1] In lieu of potatoes, 12 ounces peas or beans.

DAILY RATION OF THE RUSSIAN SOLDIER.

Peace.	Ounces.	*War.*	Ounces.
Meat	7¼	Meat	7¼
Flour or biscuit	26	Or ham	3½
Groats	4	Flour	29
Or peas or beans	14½	Sugar	¼
Or potatoes	27¼	Tea	¼
Or turnips or carrots	35	Butter	¾
Or cabbage	50	Peas or beans	5
		Groats	4¾
		Variable as in peace ration.	

ITALIAN PEACE RATION.

	Ounces.		Ounces.
Meat	7 to 11	Sugar	¾
Bread, flour, or biscuit	32½	Coffee	½
Bacon	½	Wine	8¾
Rice	5¼		

DAILY RATION OF THE AUSTRIAN SOLDIER.

Peace.	Ounces.	*War.*	Ounces.
Meat	6¾	Meat	9¾
Bread	30¾	Or salt meat or bacon	6
Or biscuit	17¾	Biscuit	3½
Flour	6¾	Flour	26¼
Or groats or barley	6½	Vegetables	5
Or potatoes	20	Potatoes	9
Rice	3¾	Peas or beans	5¼
Sauer-kraut	5½	Or potatoes.	
Butter or fat	¾	Butter or fat	1⅖
		Sugar	¾
		Coffee	¾

RATION OF THE JAPANESE SOLDIER.

Peace.	Ounces.	*War.*		Ounces.
Rice	36	Meat	(*periodically*)	16
Money allowed for other necessaries.		Fresh fruit	,,	20
		Rice	(*daily*)	36
		Vegetables	,,	4
		Bean sauce	,,	2
		Pickles or fruit	,,	2
		Sugar	,,	½
		Tea	,,	1/7
		Japanese cake	,,	8
		Sake (spirit)	,,	6½
		Cigarettes	,,	20

The food of soldiers has been considered in connection with protein (p. 103).

The *peace* ration of the British soldier is somewhat less than the French, but more than the German, peace ration. The British soldier receives *free* ¾ pound of meat and 1 pound of bread daily, which form the basis of his dietary. This is supplemented by a grocery ration, for which threepence to fourpence a day is stopped

out of the men's wages for the *mess*. The articles usually provided for it are—½ pound of bread, ¼ pound of fresh vegetables, and 1 pound of potatoes, with enough sugar, tea, coffee, and milk for the morning and evening meals, flour, rice or oatmeal, and fruit, about 1 ounce of butter daily, and condiments such as salt, pepper, and mustard, for dinner. The meat includes bone, which averages 20 per cent., so that the man gets 9·6 ounces of meat. It has been complained by men that the bone often exceeds 20 per cent., and that the men only get about 7 ounces of meat. This is probably accidental; at any rate, the bone should not exceed 20 per cent. The grocery ration varies in different regiments and corps. The hours of meals are—Breakfast, 7·30; dinner, 12·30; and tea at 4·30. The dietary is supplemented by articles purchased by the soldier for his supper, and the pay of the soldier is considered to be sufficient to allow of this being done without hardship. The system of buying their own supper is preferred by the men; it allows each man to choose his own food, thereby preventing monotony; and experience has shown that the plan works smoothly. The recruit, usually a growing youth, requires more food than the fully developed adult, and a messing allowance of 3d. a day is given them, which is commonly spent in the purchase of cakes and other sweets.

The dietary fixed for a large body of men must necessarily have a high standard for its fixed calorie value, because the needs of the men are not all on the same level, and insufficiency, as well as waste, has to be guarded against. The diet has to be varied as much as possible, experience having shown that an unvaried diet becomes distasteful, and may result in serious consequences as regards health and liability to disease. At present the balance of opinion is against cutting down the allowance of protein below 125 grammes (4¼ ounces) a day, which is included in the above dietary. The most striking deficiency in the dietary is in the class of fatty foods. The *free* ration contains only 1 ounce of butter, and the supplementary ration about ½ ounce to 1 ounce more, making a total, with fat in meat, of about 75 grammes (2½ ounces) of fat. This could be improved by giving 2 ounces of cheese and 2 ounces of bacon on alternate days, or by increasing the allowance of butter. The bread is not always wholly consumed; about ¼ pound of the *free* allowance is often wasted. There would certainly be less waste of bread if there were a greater provision of fat to eat with it. Foreign armies all receive *poor fat* rations, that of Russia containing only 27 grammes, the Germans 58, the French 72, in the service ration. The United States alone provides 100 grammes of fat in the ordinary peace ration. The table on p. 136 shows how the items of the ration are varied from day to day.

The form in which food is supplied is of no small importance. It must be pleasant to the taste and smell. In ordinary cooking the food is spiced with salt, pepper, and other condiments, which have a high dietetic value when not used to excess. There have been complaints from the occupants that the food given in barracks,

industrial schools, almshouses, and poor-houses, is devoid of proper seasoning. It is to be hoped that this stigma has been removed, for unpalatability is one of the greatest hindrances to the consumption of food, and especially of the same dietary when continued over long periods. The flavour of the foods should not be too pronounced, nor the condiments used in excess, otherwise it may become nauseous, or at the very least be provocative of indigestion, liver troubles, etc.

Diet Sheet of the 2nd Battalion of the Devonshire Regiment, for the Week ending December 9, 1907.

Date.	Meal.	Diet.
Tuesday, Dec. 3	Breakfast	Coffee, bread, butter, fresh fish.
	Dinner	Roast beef, Irish stew, boiled and baked potatoes, boiled peas.
	Tea	Tea, bread-and-butter.
Wednesday, Dec. 4	Breakfast	Tea, bread-and-butter, pies, meat, and pickles.
	Dinner	Roast beef, hot pot, boiled and baked potatoes, cabbage, plain pudding.
	Tea	Bread-and-butter and tea.
Thursday Dec. 5	Breakfast	Coffee, bread, butter, liver and potatoes.
	Dinner	Baked meat pies, sea pies, boiled potatoes, haricot beans.
	Tea	Tea, bread-and-butter
Friday, Dec. 6	Breakfast	Tea, bread, butter, and fish-cakes.
	Dinner	Roast beef, baked curry, baked and boiled potatoes, rice, and peas.
	Tea	Tea, bread and marmalade.
Saturday, Dec. 7	Breakfast	Tea, bread-and-butter.
	Dinner	Roast beef, brown stew, potatoes, butter beans, plain pudding.
	Tea	Tea, bread-and-butter.
Sunday Dec 8	Breakfast	Coffee, bread, butter, and kippers.
	Dinner	Roast beef, baked potatoes; boiled beef and carrots; boiled potatoes, cabbage, plain pudding.
	Tea	Tea, bread-and-butter.
Monday, Dec 9	Breakfast	Tea, bread, butter, sausage and potatoes.
	Dinner	Roast mutton, steamed mutton, boiled and baked potatoes, peas, and plain pudding.
	Tea	Tea, bread and marmalade.

(Signed) H. S. L. Ravenshaw.
Major commanding 2nd Devon Regiment.

The British war ration has been fixed as the result of considerable experience. Available data show that for *constant* marching and fighting about 4,500 calories of energy would be needed; but the amount of physical work done in war varies considerably, so that the ration supplied is fixed to yield somewhat less than that number of calories (see Colonel Melville's observations, p. 103). The war

rations of the British army in South Africa, of the Japanese and Russian armies in Manchuria, were as follows:

War Ration.	Protein.	Fat.	Carbo-hydrate.	Energy.
	Grammes.	Grammes.	Grammes.	Calories.
British	138	105	528	3,903
Japanese	158	27	840	4,313
Russian	187	27	775	4,891

It would be the greatest possible mistake to underfeed an army in the field; the working power would be reduced to a minimum; infection and disease would be courted. The Committee of Inquiry, appointed by the Government, expressed the opinion that observations of a more definite character than those at present available were necessary before a definite conclusion could be arrived at as to the adequacy of the British war ration.

The *peace* ration of Germany is fixed for supplying 2,611 calories from the dietary given. The *war* ration includes 181 grammes ($6\frac{5}{6}$ ounces) of protein, 64 grammes ($2\frac{1}{8}$ ounces) of fat, 558 grammes ($19\frac{7}{8}$ ounces) of carbohydrate, and 3,442 calories of available energy. Zuntz and Schumberg investigated the sufficiency of this diet. Six students were set to march in military uniforms and carrying the usual accoutrements. The observers found that there was an increased output of nitrogen due to marching, which accounted for 6 or 7 per cent. of the total energy expended; that for every 1,000 calories expended there were 800 grammes of water evaporated from the body; that a man of 70 kilos weight produced when resting 1·2 to 1·35 calories of heat per minute, and when marching with a load of 31 kilos (68·2 pounds) he produced 7·73 calories of heat per minute. The men were found to expend 3,600 calories on "resting" days, and 4,300 calories on marching days. The authors concluded that the diet should contain more fat *and sugar*, but that 110 grammes of protein is enough to maintain the nitrogenous metabolism. They found that excessive heat with a light load increases the expenditure more than a heavy load on a cold day. That the condition of fatigue increases the expenditure of energy and lameness increased waste most strikingly. As the result of *training*, there is a most perfect co-ordination of muscles; fewer muscles are used, and work is done most economically.

The Japanese Army ration in time of peace consisted until recently of an allowance of 36 ounces of rice and money for other necessaries. This food has been discussed by many people. Baron Takaki considered it in connection with the etiology of beri-beri. He agreed that the recognized amounts of nitrogen and carbon required daily by an adult are 20 grammes of nitrogen and 310 grammes of carbon, or a ratio of N : C :: 1 : 15·5. But he found that the food of the Japanese soldier or sailor contained

N : C in the proportion of 1 : 17 to 1 : 32. He proved that the greater the difference between the proportion of N to C in the Japanese diet and the recognized normal diet, the greater was the amount of beri-beri; the less difference there was, the less beri-beri occurred. He therefore concluded that beri-beri was due to a disproportion between the nitrogenous and non-nitrogenous foods in the dietary. In consequence of these investigations, fresh regulations for the dietary of the Japanese Army and Navy were issued with the object of raising the proportion of nitrogen to carbon and varying the monotony of the diet. The food now includes eggs, fish, fowl, fresh or canned beef, salt beef, salt pork, miso and shoyu (preparations of soy-beans), dried beans, bread, wheat, flour, rice, sugar, starch, butter, lard, suet, olive-oil, sesamé-oil, milk, vegetables (such as potatoes, cabbages, onions, carrots, and radishes), pickles, salt and other spices, and alcoholic liquors. Barley bread was found especially useful in preventing beri-beri.[1]

The Bengali soldier is another instance of men whose dietary has a low protein value. This arises from the fact that beef is forbidden by their religion, and they eat only small quantities of mutton, fowl, and fish; they are, in fact, vegetarians. A number of observations on the metabolism of Bengalees was made by Professor McCay, of the Calcutta Medical College.[2] After making 200 analyses, he concluded that the average daily excretion of nitrogen in the urine of the Bengali was only 5·98 grammes, as compared with 14 to 18 grammes in the European; and the urea only 12·95 grammes in the Bengali, as compared with 30 grammes in the European. Their average weight was 52 kilos, the European average being 66 or 70 kilos. Their height is the same as our own, but their chest girth is under 33 inches. The low excretion of nitrogen in the urine points to a diet poor in protein, and this dietetic peculiarity was exaggerated by the fact that the fæces contained 25 per cent. of the total nitrogen of the food, due to the large consumption of dhal or pulse, which is no better assimilated than other leguminous foods. The food of the Bengali supplies 0·11 gramme of nitrogen per kilo of body-weight, which corresponds to the demand made by Chittenden as a standard for this element. But it has not been shown that the Bengali is healthier, stronger, or possesses greater longevity, than Europeans, who eat a much larger amount of nitrogenous food. On the other hand, the Bengali is enormously inferior in activity and physical endurance to the European. Insurance offices in Calcutta rate all Bengali lives as being five years worse than European lives. At the same time, kidney disease is twice as prevalent among the natives than it is among Europeans in Calcutta, although scarlet fever is unknown in India. Colonel Melville[3] says: "As regards the power of resistance to disease, I am certain that no officer with any prolonged experience of India will deny that the native

[1] *British Medical Journal*, 1906, i. 1176.
[2] *Ibid.*, 1908, ii., 1303.
[3] *Ibid.*, 1910, ii. 1341.

is infinitely inferior to the European living under the same conditions of climate, though these are strange to the latter."

DIETARY IN THE BRITISH NAVY AND MERCANTILE MARINE.

Weekly Provision, per Man.	Admiralty Scale.			Mercantile Marine.		
	Ounces.	Grains of Carbon.	Grains of Nitrogen.	Ounces.	Grains of Carbon.	Grains of Nitrogen.
Biscuit	140	25,620	3,178	84	15,372	1,907
Flour, for puddings, etc.	9	1,521	68	32	5,408	243
Peas, for soup	8	1,288	120	$5\frac{1}{3}$	856	80
Potatoes, dried ($1\frac{1}{3}$ = 4 of fresh)	8	393	8	6	294	6
Rice	4	704	14	8	1,408	28
Oatmeal	—	—	—	8	1,376	70
Total per week ..	—	29,525	3,888	—	24,714	2,334
Total per day	—	4,216	474	—	3,530	334

In the **Navy** the ration per day is as follows: Bread, 24 ounces (680 grammes), or biscuit, 20 ounces (567 grammes); meat, 16 ounces (453 grammes); vegetables and potato, 16 ounces (453 grammes); condensed milk, $\frac{3}{4}$ ounce (21·2 grammes); sugar, 3 ounces 85 grammes); jam, 2 ounces (57·7 grammes); coffee and tea, $\frac{3}{4}$ ounce (21·2 grammes); salt, $\frac{1}{4}$ ounce (7·1 gramme); rum, $2\frac{1}{2}$ ounces (72 grammes). Five days in the week the meat consists of 16 ounces of fresh meat; but on the other two days, 4 ounces of fresh meat and 12 ounces of salt beef or salt pork, and peasoup or white beans. Four days a week there is an allowance of 8 ounces of *fresh* potatoes, or an equivalent amount of dried ones; three days a week there is a smaller allowance of potatoes, but 3 ounces of fresh vegetables in addition. Then there is flour, suet, rice, tapioca, and raisins, for puddings; curry powder; oatmeal; butter; marmalade; tea; sugar, etc. Breakfast consists of curry, stew, or hashed meat; dinner of soup, roast or boiled meat, vegetables, and pudding; tea of bread-and-butter and jam or marmalade. The ration has an official *value of* 10*d.* per diem. The allowance of nutriment is sufficient, even liberal; but the last regular meal or "tea" is not substantial enough, considering the length of time between it and the breakfast next morning. In 1907 a Departmental Committee was appointed to inquire into the victualling arrangements in the fleet, and a report was made by the Committee, recommending the adoption of a standard ration having an approximate *value of sixpence a day*, but with a messing allowance of fourpence per man. It was believed that this would give the men more choice in the selection of their food, and allow them to purchase supper if they wished to do so. The standard ration suggested by them for use

during service at sea is as follows: 1 pound bread (or ¾ pound bread and ¼ pound flour); ½ pound fresh meat; 1 pound fresh vegetables; 4 ounces sugar; ½ ounce tea or 1 ounce coffee in lieu of ¼ ounce tea, or ½ ounce cocoa for ¼ ounce tea or 1 ounce coffee; ¾ ounce condensed milk; 4 ounces preserved meat once a week while in harbour, and twice a week when at sea; condiments as required.

According to this recommendation of the Committee, the bread ration is reduced from 1½ to 1 pound a day; they also recommend that soft bread be given to the men every day on ships which have a bakery, the present weekly biscuit day being abolished. Hard biscuit is not a palatable substitute for bread, and should only be used when an absolute necessity arises. The Committee suggested that the biscuit ration should be reduced from 1¼ pounds to ½ pound, and that a new type of biscuit be provided in place of the present hard and unpopular variety. They further proposed a reduction of the fresh meat ration from ¾ to ½ pound per man, which they found to be the average consumption in the fleet, but to allow an additional ¼ pound per man to be taken up if desired, on payment for same out of the "messing allowance," at a charge of 4d. per pound; while the ration in war-time and under arduous duties should remain at ¾ pound of fresh meat per man. The salt pork ration was also recommended to be reduced from ¾ to ½ pound per man, and the preserved meat ration from 9 to 6 ounces.

The food on a merchant ship is as follows (*weekly allowance*):

FOOD ON A MERCHANT SHIP: EACH MAN PER WEEK.[1]

	Grammes.	Ounces.
Bread *ad libitum*	—	—
Pork or beef three days a week	303	10½
Salt beef three days a week	625	22
Preserved meat two days a week	250	8⅘
Dried fish one day a week	350	12 3/10
Fish-balls one day a week	350	12 3/10
Potatoes per week	3,000	105
Vegetables, fresh or salt	1,100	38
Dried fruit (raisins, etc.)	150	5 2/10
Condensed milk	150	5 2/10
Coffee	225	7 9/10
Tea	25	⅘
Sugar	350	12 2/10
Butter or marmalade	500	17 6/10
Oatmeal	500	17 6/10
Peas, beans, or rice	332	11 7/10
Lime-juice	175	5⅗
Salt, pepper, mustard, and vinegar *ad lib.* ..	—	—

[1] *British Medical Journal*, 1908, i. 1099.

With regard to vegetables, the Committee recommended that the allowance of 1 pound of vegetables per man with fresh meat should be retained, and that a ration of ½ pound of potatoes per man should be served with salt pork or preserved meat. The fresh milk ration was increased from $\frac{1}{6}$ to $\frac{1}{4}$ pint per man; the sugar from 3 to 4 ounces; the tea from $\frac{3}{8}$ to ½ ounce; the cocoa to be reduced accordingly from $\frac{5}{8}$ to ½ ounce, and coffee allowed as an alternative; the jam to be reduced from 2 ounces to 1 ounce.

The following is an example of the bill of fare:

SEAMAN'S BILL OF FARE.

Day.	Breakfast.	Dinner.	Supper.
Every day ..	Coffee, biscuit, butter, marmalade	Biscuit and switchel	Tea, biscuit, butter, marmalade.
Sunday	Dry hash, soft bread	Sea pie, plum-duff	Cold beef and pickles.
Monday	Irish stew	Peasoup, pork, and cavalances	Dry hash.
Tuesday ..	Rice and molasses	Salt beef, potatoes, plum-duff	Cold meat and pickles.
Wednesday ..	Porridge and molasses	Sea pie	Potato stew.
Thursday ..	Bread scowse	Peasoup, pork, and cavalances	Cold pork and pickles.
Friday	Dry hash	Preserved meat or salt fish and potatoes	Fish
Saturday ..	Porridge and molasses	Salt beef, rice, and molasses	Cold meat and pickles.

Prison Dietary.—The ordinary diet consists of—Breakfast: a pint of oatmeal gruel, and bread. Dinner: beans, bacon, and potatoes; stewed beef and potatoes; or mutton and potatoes, alternatively. Supper: a pint of gruel, and bread. Prisoners who are not in good health have whatever the doctor orders them. The diet No. IV. for men doing *hard labour* in English prisons may be taken as an example for consideration: Breakfast: bread, 8 ounces; and gruel or porridge, 1 pint. Dinner: (*a*) bread, 6 ounces; potato, 8 ounces; suet pudding, 12 ounces; or (*b*) bread, 8 ounces; potato, 12 ounces; cooked meat, free from bone, 4 ounces; or (*c*) bread, 8 ounces; potato, 12 ounces; soup, 1 pint. Supper: bread, 6 or 8 ounces; gruel or porridge, 1 pint.

The meat is beef; bread is made from whole meal; gruel is made with 2 ounces, and porridge with 3 ounces, of coarse oatmeal to each pint of water, and salt. The suet pudding contains 1½ ounces of mutton suet, 8 ounces of flour, and 6½ ounces of water to each pound, with sufficient salt. Each pint of soup contains 4 ounces of meat, 4 ounces of split peas, 2 ounces of fresh vegetables, 1½ ounces of onions, with pepper and salt. The entire daily ration contains

116 grammes of protein, 37 grammes of fat, and 572 grammes of carbohydrate, and yields 3,125 calories. This is considered a generous allowance, although the dietary is deficient in fat, perhaps intentionally so; for the dietaries of Playfair, who gave considerable attention to the food of prisoners, all have that characteristic. The amounts being transformed from ounces into grammes, Playfair's prison dietaries are—

Prison Dietaries.	Protein.	Fat.	Carbo-hydrate.	Salts	Energy.
Detention:	Grammes.	Grammes.	Grammes.	Grammes.	Calories.
Under seven days	51	14	304	—	1,626
,, twenty-one days ..	68	17	425	—	2,179
With light labour	100	9	470	—	2,420
Industrial labour	105	44	495	46	2,870
Hard labour	116	44	534	14	3,075
Punishment	36	7	230	10	1,154

The dietaries of English prisons are well chosen and good on the whole. An investigation into them was made in 1899 by Crawford Dunlop,[1] who reported to the Commissioners thereon. He reported that, even when engaged in the most active form of prison labour, the prisoner works for a shorter time and has a longer rest than the ordinary free labourer. He concluded from this that the food required by a prisoner is not more than that required by the free labourer. He therefore considered that the standard diet for moderate or ordinary work was applicable to the prisoners, and recommended that the prisoners' dietary should contain 120 grammes of protein, 38 grammes of fat, and *not more than* 550 grammes of carbohydrate. He recommended that the energy value of the food for ordinary prisoners should be 3,100 calories; that an extra allowance of protein and fat (*e.g.*, meat) should be given those performing severe labours; and also an extra allowance should be made for large men and nursing-mothers. As the average woman requires less food than a man, he recommended an allowance of protein 96, fat 30, carbohydrate 440, grammes, having an energy value of 2,480 calories, as sufficient for women doing moderate work. For juveniles under sixteen years he recommended Camerer's standard dietary as sufficient—viz., protein 75, fat 42, carbohydrates 325, grammes, yielding 2,040 calories.

Poor-House Dietaries.—The following examples of the dietaries in Union Workhouses is sufficient to indicate their scope:

I. CARDIFF UNION.

Weekly Dietary for Males, Classes 1 *and* 1A (*Able-bodied Paupers and Others out of the Infirmary*).

Breakfast.—Bread, 8 ounces on four days, 4 ounces on two days, none on one day; porridge, 1½ pints on three days (when bread is diminished); milk, 1 pint on four days (when 8 ounces bread are given); ½ ounce butter on Sunday only.

[1] "Report on Prison Dietaries," the *Lancet*, October 21, 1899.

Lunch, 10 *a.m.*—Bread, 4 ounces; cheese, 1½ ounces.

Dinner.—Bread, 4, 6, or 8 ounces, according to amount of meat; potato or other vegetables, 12 ounces on three days a week. The "meat ration" is as follows: Cooked meat (without bone), 4½ ounces (two days); hashed meat, 6 ounces (one day); cheese, 3 ounces (one day); Irish stew, 1 pint (one day); soup, 1½ pints (one day); suet pudding, 1 pound (one day). Coffee, 1 pint, when cheese replaces meat.

Supper.—Bread, 4, 6, or 8 ounces; gruel, 1½ pints (three days with 6 ounces bread); porridge, 1½ pint (one day with 4 ounces bread); butter, ½ ounce (one day with 8 ounces bread and 1 pint tea); cheese, 2 ounces (on two days); broth, 1 pint (two days).

Weekly Dietary for Males, Classes 2 *and* 2A (*Infirm Persons*).

Breakfast.—Bread, 8 ounces; butter, ½ ounce; coffee, tea, or cocoa, 1 pint.

Lunch, 10 *a.m.*—Bread, 4 ounces; cheese, 1½ ounces.

Dinner.—Meat without bone, 4½ ounces (three days); hashed meat, 4 ounces (one day); soup, 1½ pints (one day); Irish stew, 1 pint (one day); cheese, 3 ounces (one day); coffee, 1 pint when cheese replaces meat; bread, 4, 6, or 8 ounces, according to amount of meat, etc.; potatoes or other vegetables, 6 or 12 ounces (four days); fruit pudding, 4 ounces (one day).

Supper.—Bread (six days), 8 ounces; cake, 6 ounces (one day); butter, ½ ounce; tea, 1 pint.

II. Chorley Union.

Weekly Dietary for Males, Classes 1 *and* 1A (*Able-bodied Paupers and Others out of Infirmary*).

Breakfast.—Sunday: Bread, 8 ounces; margarine, ½ ounce; coffee, 1 pint. On the other days: Porridge, 1½ pints; treacle, 1½ ounces.

Lunch.—Class 1A only: Bread, 4 ounces; cheese, 1½ ounces.

Dinner.—Meat without bone, 4½ ounces (two days); bacon, 3 ounces (one day); meat stew, 1 pint (one day); soup, 1½ pints (one day); Irish stew, 1 pint (one day); potato pie, 1 pound (one day); vegetables and potatoes, 12 ounces (three days).

Supper.—Sunday: Bread, 8 ounces; margarine, ½ ounce; tea, 1 pint; Other days: Bread, 6 ounces; gruel, 1½ pints.

Weekly Dietary for Men, Classes 2 *and* 2A (*Infirm Persons*).

Breakfast.—Bread, 8 ounces; margarine, ½ ounce; coffee or cocoa, 1 pint.

Lunch.—Class 2A only: Bread, 4 ounces; margarine, ½ ounce, or cheese 1½ ounces.

Dinner.—Meat without bone, 4½ ounces (three days); soup, 1 pint (one day); meat stew, 1 pint (one day); potato pie, 1 pound (one day); pudding, 8 ounces (one day); vegetables or potatoes, 12 ounces (four days).

Supper.—Bread, 8 ounces; margarine, ½ ounce; tea, 1 pint; cake, 6 ounces on Sundays instead of bread.

Weekly Food Allowance for the Officers in a Union Poorhouse.

Bread, 7 pounds; meat or fish, 7 pounds; bacon, 1 pound; butter, 1 pound; milk, 7 pints; cheese, ¾ pound; 4 eggs; tea, ½ pound, or coffee, 1 pound; loaf sugar, 1 pound; raw sugar, ½ pound; jam or marmalade, ½ pound; flour, rice, currants, raisins, pickles, condiments, potatoes and vegetables, as much as is required.

The food of poor-houses and aged people's homes in America may be considered for comparison with the former. As an example, the food consumed *during one week* in a Home for Aged Women

in Philadelphia may be taken. The inmates consisted of 113 women, 10 aged sixty-five to seventy years, 73 aged seventy to eighty, 20 aged eighty to ninety, and 10 between ninety and one hundred years. The total food consumed in the Home during the week under consideration was as follows:[1]

Supply of Food in a Home for Aged Women, Week ending May 14, 1907.

	Pounds.		Pounds.
Ribs of beef	112	Breakfast foods	9
Rump steak	37½	White bread	146
Dried beef	$12\frac{8}{10}$	Graham bread	48½
Calf's liver	11	Breakfast rolls	18
Lamb chops	10	Cake (Dutch cake)	21
Shoulder of mutton	39½	Cookies	5½
Bacon	17	Macaroni	3½
Ham	$23\frac{8}{10}$	Corn starch	$2\frac{8}{10}$
Salt pork	6	Sugar	185½
Lard	2½	Molasses	2
Mackerel	19	Dried peas	10
Shad	64	Lima beans	$7\frac{8}{10}$
Canned oysters	3	Potatoes	232½
Eggs	76	Cabbage	39½
Butter	71½	Lettuce	32½
Cheese	4	Onions	2½
Milk	922	Radishes	3½
Buttermilk	30	Spinach	52
Olive-oil	1	Fresh tomatoes	1
Pearl barley	$1\frac{3}{10}$	Canned tomatoes	20½
Cornmeal	21	Bananas	78
Oatmeal	21	Rhubarb	24½
Rice	13½	Strawberries	70
Wheat-flour	63	Canned plums	25
Farina	5	Dried prunes	10

After allowing for waste and the food consumed by the employees, the dietary gave for *each woman* an average of 58 grammes of protein, 83 grammes of fat, 228 grammes of carbohydrate, and 1,882 calories, and a cost of 18 cents per day. The variety of foods is remarkable, and the number of kinds of fruit and vegetables adds largely to the nutritive value of the food by stimulating digestion, which is a matter of great importance in old persons. The bread is supplied in 2-pound loaves, baked in a tin, thus avoiding an excess of crust, which would probably be wasted. Coffee, tea, and milk are always served for breakfast, tea or coffee and milk for dinner, and tea and milk for supper. *The quantity of food allowed to each person is unlimited.* Meat or fish is given with every dinner; meat left from dinner is served at supper to the few persons who desire it. Roast beef is served cold for dinner on Sunday. Potatoes and green vegetables are given every day. Rice or rice-pudding is served nearly every day. A hot dish is provided for supper except on Sunday, when it is replaced by

[1] Bulletin 223, U.S. Department of Agriculture, Experimental Station.

cake. Dessert is given most days. The following is a sample menu:

Breakfast.—Oatmeal, dry flaked cereal, chipped beef, potatoes, bread, butter, tea, coffee, milk, and sugar.

Dinner.—Fried ham, mashed potatoes, lettuce with salad dressing; boiled rice; coffee, bread-and-butter.

Supper.—Corn muffins, butter, tomato preserves, tea, milk.

Another example may be taken from Bayview Asylum.[1] This institution, while not being primarily an insane asylum, admits pauper insane persons and treats them in a separate ward. It is an institution for the aged and infirm who are unable to support themselves or find others to support them. It is in every respect a counterpart of an English workhouse or poorhouse. The inmates vary from middle life to old age, males and females being in about the same number. In the men's dining-room *the ration system* is followed entirely, except with regard to bread, which is allowed *ad libitum.* The menu for one week was as follows:

May 8.—Roast beef, boiled beef, soup, hash (boiled meat and potatoes), bread, milk, sugar, baked potatoes, apple sauce.

May 9.—Soup, hash, boiled pork, bread, milk, sugar.

May 10.—Soup, hash, roast beef, boiled pork, radishes, bread, milk, sugar.

May 11.—Soup, hash, boiled beef, roast beef, boiled pork, boiled potatoes, bread, milk, sugar.

May 12.—Baked herring, hash, boiled pork, bread, sugar, milk.

May 13.—Soup, hash, bread, butter, radishes, sugar, milk.

May 14.—Hash, roast beef, boiled pork, cabbage, potatoes, bread, milk, sugar.

The entire dietary, after deducting waste, included 144 grammes of protein, and 2,901 calories per day per man. The food was given at three meals a day, a sample of its distribution being as follows:

Breakfast.—Boiled oatmeal, milk, bread, butter, eggs, tea, and coffee.

Dinner.—Beef soup, with vegetables and bread.

Supper.—Bread, and coffee.

On the same day the able-bodied women received:

Breakfast.—Oatmeal, milk, Hamburg steak, bread, butter, tea, and coffee.

Dinner.—Bacon, beef soup, vegetables, rice, milk, and bread.

Supper.—Bread, butter, tea, and coffee.

The women's food, derived from a dietary for the week similar to the men's, gave 85 grammes of protein and 1,924 calories a day per woman.

Orphanage Dietaries.—The following was formerly the menu of an orphan home for girls between four and seventeen years of age:

Breakfast.—Bread and dripping, milk and water.

Dinner.—Monday: Vegetable soup. Tuesday: Peasoup. Wednesday: Suet pudding and treacle. Thursday: Bread and cheese. Friday: Rice pudding. Saturday: Fried fish. Sunday: Bread-and-butter pudding.

Tea.—Bread and dripping, cocoa made from nibs.

[1] Bulletin 223, U.S. Department of Agriculture, Experimental Station.

The amount of meat used for making the soups, and the amount of milk, sugar, peas, rice, etc., is not stated. *It is a bad example* of dietary for children. The amount of bread should be unlimited, and the meat should vary according to the age of the child. A child of six or seven years requires 3½ or 4 ounces of meat daily; a boy of nine or ten years, 6 ounces; and youths of fifteen or sixteen years, 9 ounces of meat free from bone. The children in orphanages and similar institutions are the most likely to suffer a deficiency of animal food because of its cost. Orphanages should be under Government inspection, and the dietary from week to week ought to be reported to a Government official, whose duty it should be to check the quantity and quality of the food. When the cost of meat is greater than the revenue of an institution of this character will bear, the advantages of peas, beans, lentils, and nuts, as sources of protein, should be impressed upon the managers. Whatever variety of diet is provided, it should always be sufficiently abundant to satisfy the cravings of hunger, it should contain not less than 2 grammes of protein per kilo of body-weight (thereby allowing 0·5 gramme per kilo for growth), it should contain about the same proportion of fat, and the carbohydrate, exemplified by bread, should be unstinted. Such a dietary might consist of the following articles:

Scheme of Dietary for an Orphanage.

Breakfast.

Oatmeal porridge or hominy, ½ pint of milk, sugar, tea, boiled bacon, and bread.

Dinner.

Sunday.—Roast beef, potatoes, vegetables, Yorkshire pudding.
Monday.—Soup (made from bones), lentil flour, carrots, onions, bread, cheese.
Tuesday.—Hashed beef (remains of Sunday's dinner), haricot beans, potato, turnips, bread.
Wednesday.—Roast neck of mutton, potatoes, cabbage, bread.
Thursday.—Peasoup (made with mutton bones), bread, rice pudding.
Friday.—Irish stew (made from scraps of meat from butcher), potatoes, and onions, boiled suet-pudding.
Saturday.—Bone soup (made from bones specially bought and broken), haricot beans, bread, and margarine.

Tea or Supper.

Tea, bread, margarine, raw onions, lettuce, jam, marmalade.

The following excellent dietary[1] is that of a *Convalescent Home* for Children:

Breakfast.

Porridge with new milk, or sausages, or eggs, or liver and bacon, or cold ham, or dried fish, and bread-and-butter or dripping.

[1] *Brit. Med. Jour.*, 1909, ii. 555.

Dinner.

Monday.—Cold beef or lamb (minced meat for young children), potatoes, salad, pickles; milk pudding, or pastry, or stewed fruit.
Tuesday.—Irish stew, with carrots and onions; suet pudding or milk pudding.
Wednesday.—Roast mutton, mint sauce, potatoes, cauliflowers; Genoese paste sandwiches, milk pudding.
Thursday.—Rabbit-pie, cabbage; open tarts, milk pudding.
Friday.—Fish, or beans and bacon, or Irish stew; pastry, stewed fruit, milk pudding.
Saturday.—Cold meat, mint sauce, salad, pickles; corn-starch shapes and jam; cheese.
Sunday.—Roast beef, peas, potatoes; fruit tart, stewed fruit, milk-pudding.

Tea.

Tea or new milk (according to age), bread, butter, lettuce, or raw onions, jam, cake.

Supper.

Milk, soup, bread-and-butter or dripping, or cold meat and cold milk pudding, according to age.

The dietary of children is still further discussed in a chapter on the feeding of infants and children; but the following dietaries may be quoted here, especially as they were prepared for philanthropic purposes. The importance of seeing that school children are properly fed cannot be over-rated; and this has been fully recognized by the various educational authorities during the past quarter of a century. As far distant as 1886 the Birmingham School Board instituted *farthing dinners* for necessitous children. The *rationale* was based on the nutritive efficiency of the legumes; the meal consisted of soup made from peas, lentils, or maize, or cocoa and milk with bread and jam, or bread and milk. The actual cost of the meal varied from 0·39 to 0·53 pence per head, and averaged 0·45 pence per head for 356,480 dinners.

At a later date Niven, of Manchester, recommended the following three meals for school children who were provided *free meals* :

First Meal.—Two ounces of oatmeal and 2 ounces of sugar made into porridge. It contains 8·16 grammes protein, 5·62 of fat, and yields 287·5 calories.
Second Meal.—One pint of peasoup containing 4 ounces of peas, with 8 ounces of bread. This contains 38·6 grammes protein, 4 grammes fat, and 987·5 calories.
Third Meal.—Eight ounces of bread and 1 ounce of margarine or dripping. It contains 15 grammes protein, 24 grammes fat, and yields 804·6 calories.

Dr. Niven estimates that a child of seven years requires daily 62·5 grammes of protein and 1,750 calories of energy, and that his three meals contain enough to supply them. The dietary is somewhat deficient in fat, which could be improved by giving margarine or dripping to the bread in the second meal. Niven considers that the gain in wealth to the community obtained by passing children on to the working period in a state of physical efficiency would be so enormous as to fully justify the additional burden

by taxation which would arise from feeding necessitous children at school; and concludes that such feeding ought to be done by the State or municipality.

The Food for Athletes.—It has been a custom for generations past, when the body is being "trained" for arduous work, to consume a larger portion of protein foods than at ordinary times. During training at Oxford University the *breakfast* consists of underdone beef or mutton, dry toast or crust of bread, and one cupful of tea; the *midday meal* of meat, but no vegetables or pudding, and a pint of beer; the *evening meal* of cold meat, watercress or other green salad, and a pint of beer. According to Maclaren, the food at Cambridge University is similar, but more vegetables are allowed. King, the trainer, adopted the following regimen: *Breakfast:* two mutton chops with a small amount of dry toast, stale bread, or crust, and a cup of tea without sugar. *Dinner:* $1\frac{1}{4}$ pounds lean beef or mutton, greens, one potato, toast or stale bread, and $\frac{1}{2}$ pint of ale. *Tea:* an egg with dry toast and a cup of tea. *Supper:* $\frac{1}{2}$ pint of ale or gruel. If nothing is taken at teatime, the supper may consist of cold meat, lettuce, watercress, a little stale bread, and a pint of beer. The exercise consists of walking up to twenty miles a day, and rowing, cricket, boxing, or other exercise in which it is desired to excel. The object is to reduce fat, and develop muscle, or strength, activity, and endurance. If this regime is carried too far, the body is "over-trained" and weakened. If the subject is still encumbered with fat, he is considered "under-trained."

Is it possible to regulate the diet so as to produce a gain of muscular tissue? Such a process normally occurs during growth, convalescence, and after a period of insufficient food. Experiments on animals have shown that, when the food contains an excess of protein, some of it may be stored in the cells as reserve protein and a part may be utilized for the formation of new cells. But there is no evidence in favour of the consumption of an excess of protein for this purpose. The training diet is chiefly of use in reducing fat. It is, however, undoubted that groups of muscle can be increased in size and volume by training. But the increase is not due to food alone; it is a hyperplasia or work-hypertrophy, due to stimulation by increased activity, the inherent power of growth in the cells, and a sufficiency of nutriment. There is no evidence that a great increase of protein encourages the growth of muscle beyond moderate limits. The protein required for this purpose is furnished by the blood, which is made to circulate more freely through the tissues by exercise, and it is very little more than that required in ordinary circumstances. The amount required is certainly no more than a child requires during the most active period of growth—viz., 1·75 to 2·0 grammes of protein per kilo of body-weight, and therefore the allowance during training for a man of 154 pounds (70 kilos) should be from 123 to 140 grammes daily. There is evidence to show that when the protein consumed exceeds 190 grammes daily, the retained nitrogen does not amount

to more than 5 or 6 grammes a day, and that for only a short period.

It should not be overlooked, in connection with increased muscular work, that the immediate source of muscular energy is a carbohydrate. This fact depreciates the value of the long-established training diets. King's diet, detailed above, contains 240 grammes of protein and 2,540 calories; but the amount of carbohydrate is only 130 grammes, and the total food-value no more than would be required by a man doing very light work. Such a diet is physiologically wrong; its chief value lies in being a fat-reducer. It is not a strengthening diet. The diet for increased muscular work, athletic, or other exercise, must consist of a general increase of the standard diet, with a leaning towards carbohydrates. Benedict considers a proper diet would contain 2·5 grammes of protein and 70 or 80 calories per kilo of body-weight, or 175 grammes of protein and 430 to 500 grammes of carbohydrate. The following table gives examples of the food actually consumed by various athletes:

THE FOOD OF ATHLETES UNDER OBSERVATION.

Subject.	Protein.	Fat.	Carbohydrate.	Energy.
	Grammes.	Grammes.	Grammes.	Calories.
Boat crews of Yale and Harvard Universities	135	177	440	4,085
Captain of Harvard crew	155	181	487	4,315
Football team in Connecticut ..	181	292	557	5,470
,, ,, ,, California ..	270	416	710	7,885
Athletes at Helsinfors	217	259	431	5,070
,, ,, ,, ...	182	204	392	4,254
A professional athlete	244	151	502	4,460

The value of the old dietaries consists in the reduction of fat; by the combination of diet, exercise, and massage, superfluous fat is reduced. When the body is well-trained, it has not an ounce of unnecessary fat, the muscles are firm and tough, the heart and lungs in good working order, and the highest degree of strength, activity, and endurance, is attained. But to insure the continuance of this condition the excessive consumption of protein, to the exclusion of carbohydrate, must not be carried on too long. There is no advantage, in fact a disadvantage, in cutting down carbohydrates when the body has attained a proper condition.

The Food to be consumed during Severe Exercise.—In an exercise of short duration no food is required; but during prolonged exertion, in swimming, walking, climbing, riding, cycling, etc., it is necessary to take some nourishment, which should consist chiefly of water and substances dissolved therein. The nutrients of special value are sugar and albumin in an assimilable form; substances containing creatin—*e.g.*, beef-tea, meat-extract, yeast-extract, also

tea and coffee; or a small amount of alcohol *near the end of the exercise*; plain water, barley or oatmeal water. The value of sugar as a stimulant to tired muscles is abundantly proved by experience and confirmed by the ergograph. It may be taken in tea, coffee, lemon-water, barley-water, chocolate, candy, or ordinary lump sugar to the extent of 2 ounces a day. Some people prefer to take it in raisins or dates, which are also somewhat demulcent. Next to sugar, albumin in the form of raw eggs, white of egg and extract of meat, or white of egg and lemon-water, is the most important food to be taken during prolonged exertion. Water in various forms should be taken freely. The athlete should be warned against drinking a large amount of milk when overheated. A small meal every two hours is better than a large meal with a greater interval. In long-distance walking—*e.g.*, 100 miles in twenty-four hours—failure often arises from the condition known as "walkers' stomach," in which there is pain in the epigastrium, belching, nausea, and sometimes vomiting. It is probably due to the consumption of solid food during the exercise; the psychic gastric juice is absent, the increased circulation through the voluntary muscles causes more or less anæmia of the splanchnic area with diminution of the gastric juice, and the diminution of HCl favours the evolution of gas. At the same time there is a diminution of the osmotic pressure in the stomach, but an increase of the pressure of the gases in the blood, owing to the great activity of the body, whence there is a reversal of the ordinary process, CO_2 being excreted through the stomach as well as the lungs.

The Food required for Mental Work.—There is no evidence from experiments that mental activity exercises any demonstrable influence on the metabolism of nitrogen and carbon; the energy used in brain-work is not measurable by the most careful calorimetric observations. The actual energy set free by a nervous impulse is so small that the chemical changes attending it cannot be recognized by any means at our disposal. Nevertheless, cerebral activity is attended by molecular changes in the cells; there is a metabolism of cerebrin, protagon, lecithin, cholesterin, and other phosphorized fats. Repeated observation shows that during intellectual labour the absorption of nitrogen and phosphoric acid from the alimentary canal is diminished as compared with absorption during repose and after mental work. As regards elimination, Mairet and Florence[1] found more nitrogen and phosphoric acid are excreted in the urine than absorbed during mental work. Hoppe-Seyler says it has never been proved that the excretion of phosphoric acid is increased by mental work; and Halliburton says that in any case the amount of phosphoric acid arising from cerebral metabolism must be very small. While admitting, therefore, that the expenditure of material in the performance of mental work is small, it is necessary to point out the indirect but great influence of brain-work on the entire organism. The closeness and intricacy

[1] "Le Travail Intellectual et les Fonctions de l'Organisme," 1907.

of the ties which bind all parts of the organism together is shown by the tendency of mental work, worry, and anxiety, to derange the digestive and general metabolic functions of the body. If, therefore, any special diet is required by brain-workers, it bears no particular relation to the brain, but it must have a special reference to the alimentary organs. Any arrangement of the food for facilitating brain-work must be directed to lightening the labour of the stomach and keeping the liver and eliminating organs in healthy action. A man whose work is sedentary and chiefly mental does not require so much food as a man doing muscular work. Under such circumstances the expenditure of the body varies from 32 to 35 calories per kilo, or about 2,250 to 2,450 calories for a man of average weight. As regards protein, it has been shown that mental work can be done on an allowance of 0·75 gramme per kilo, or from 52 to 57 grammes of protein daily for a man of 154 pounds. The author does not agree with so small an allowance, but considers an allowance of 1 gramme per kilo, or 70 grammes daily, is small enough, and 1·5 grammes per kilo is nearer the normal requirement. The importance of fat in the food is shown by the fact that muscle contains 3 per cent., brain 9 per cent., and nerves 22 per cent., of fat. The amount of carbohydrate required is smaller than for muscular work. When these facts are considered, the dietary of Ranke, now classical, appears to be typical of what the brain-worker requires—viz., protein 100 grammes, fat 100 grammes, carbohydrate 240 grammes, and energy 2,310 calories.

The diet should not be bulky; it should be light and digestible, and may be selected from the following articles: Fish—sole, plaice, whiting, haddock, brill, turbot, skate, flounder, cod, oysters; lamb, mutton, tender beef (free from skin and gristle); pheasant, fowl, rabbit; eggs, bacon, fat ham; milk, cream, cream-cheese, butter; stale bread, dry toast, zwiebach, biscuit (crackers); oatmeal; blanc-mange, junket, custard, jelly, milk puddings, potatoes, asparagus, seakale, spinach, cauliflower, vegetable marrow (squash), kidney beans, green peas; small quantities of cabbage, savoy, kale, Brussels-sprouts; and purée of carrots, turnips, or swedes (ruta-baga). Cooked fruits may be eaten in moderation, as well as a small amount of fresh fruit. Tea, coffee, and cocoa should constitute the chief beverages. Sir W. Roberts says: "They are not inappropriately termed *brain-foods*, and must be regarded as a very important part of the equipment for the struggle for that higher and better existence which is almost exclusively a brain struggle." Fish is chiefly of value because it is light and easily digested, and not because it has any special claim to be regarded as a brain-food. Excess of food is bad for everybody, but especially for the brain-worker. Heavy foods are particularly bad for him, because they produce heaviness, dulness, and drowsiness. Spiced foods and rich foods upset the alimentary functions, whereby the circulation is flooded with the products of imperfect metabolism to the detriment of the brain. Water is the best beverage to take with the meals,

but the use of tea and coffee is commendable; they have an invigorating effect arising from caffein and essential oils. There is sometimes a tendency to abuse these valuable foods. This is a mistake, and may lead to the development of undesirable effects and interference with brain-work. Alcohol may or may not assist the brain-worker. It may be necessary, owing to some idiosyncrasy of the individual. The primary effect of alcohol is stimulation of the brain; it makes it quick and active; it excites the imagination, creates a light and free phaseology and a gay and hilarious volubility, or prolonged verbosity may result; but this is followed by a secondary depression during which the intellect is blunted, the mind is dull, and its vivacity is suppressed. Indeed, it has been proved again and again that, when mental work is the regular occupation, the fullest and best results are obtained without its aid, that the depression or fatigue following stimulation by alcohol is greater than the fatigue from mental work performed without it. As regards special mental efforts, many observations have been made. Kraepelin of Heidelberg investigated this matter in various subjects after they had taken a small dose of alcohol (½ to 1 ounce of whisky). The exercises were reading aloud, adding columns of figures, making arithmetical calculations, and committing figures to memory. Reading was quickened, but mistakes were more frequent; the power to add figures was not improved, but declined after taking the alcohol for twelve days; 100 figures were correctly memorized by 40 repetitions without alcohol, but only 60 figures were correctly given after 60 repetitions under its influence. McDougall tested its effects on the attention, and found the subjects made 53 per cent. more errors when they consumed from 1 to 3 ounces of whisky than when none was taken. I join with those who find mental work cannot be done so well with alcohol as without it. Alcohol excites the imagination and gives an increased feeling of importance, it promotes the flow of language, raises the spirits, enlivens the mind, and sharpens the wit. This stimulation is due to an increased flow of blood through the brain, which causes a quickening of the cerebral functions. But this effect is comparatively brief in duration—too short to be of any use to the man whose daily bread depends on the results of brain-work. It is the condition of the after-dinner speaker, whose imagination is brisk, thoughts fluent, and language fervid. The after-dinner speech, so brilliant and witty, unless previously thought-out, is apt to be unsatisfactory to the orator in his cooler moments; alcohol interferes with the power of clear judgment and criticism, and the emotions come into play uncontrolled by the guiding influence of reason.

It may be necessary for the brain-worker to take a little beer, wine, or diluted spirits, for some other purpose than stimulating his cerebral faculties. As an appetizer and invigorator a moderate amount may be of value to the individual whose stomach has lost tone through a sedentary life, overwork, or worry. But the amount must be kept within very small limits if the head is to be kept clear,

the stomach free from catarrh, and the liver in working order—all points of importance when work depends upon a clear head, mental activity, and a feeling of well-being.

The Influence of Climate on Diet.—The performance of mechanical labour necessitates the same expenditure of energy in every climate. But the climate influences the radiation of heat from the body; this is greater in a cold or wet climate and less in a hot than in a temperate climate. Therefore, *a priori*, more food is required in a cold and less in a hot than in a temperate climate. But it is modified by circumstances. Civilized people prevent the greater loss of heat in a cold climate by living in warm houses and wearing warm clothing; and they promote the radiation of heat and evaporation from their body in a warm climate by wearing thin clothing.

When the body is exposed to a low temperature, there is an increase of metabolism resulting in the discharge of a larger quantity of CO_2, which should be met by a corresponding increase in the consumption of carbonaceous foods. Fat supplies twice as much heat as the same amount of carbohydrate, while protein supples about the same heat as carbohydrate; therefore the increased consumption of animal food is a scientific procedure which is instinctively adopted by the natives, and this rule may be safely followed by visitors to Arctic and other cold regions.

When a body is exposed to the greater heat of tropical climates, the metabolism is slightly decreased, but the production of heat is not much less than in a temperate climate. Whence it is concluded that it is not necessary to take less food in hot climates, but to slightly increase the intake of carbohydrates to supply the heat radiated from the skin, and with the special object of promoting perspiration. The natives of hot climates, as a rule, consume less animal food and more vegetables and fruit than those of temperate regions. This may be considered a good rule to be followed by those from temperate regions who go to live in the tropics; but such a conclusion is questionable. Medical testimony and scientific fact are somewhat opposed to it. Long centuries of usage has accustomed the natives to consume large quantities of rice, millet, dhal (pulse), manioc, and other vegetables; but a person unaccustomed to such diet would be unable to consume and digest it—the bulk would be too much for him. Moreover, it is a low protein diet, and it is established that there should be a definite ratio between the proportion of nitrogen and carbon in the food. The metabolism of nitrogen and carbon is very little disturbed by transferring the body from one region of the earth to another; but it is greatly influenced by exercise or its absence. There are exceptions to the rule of vegetarianism even among the natives. The Arabs of East Africa, the Abyssinians, the Pampas Indians, are all consumers of great quantities of meat, but they are very active people. Moreover, the consumption of meat is largely controlled by religion. The ox is sacred to 250 millions of inhabitants in India. The hog is an abomination to the Hindus and Moham-

medans, as it was to the ancient Egyptians and is to the Hebrews to-day. In Bengal, Madras, Assam, Burmah, and Siam the food of the people consists of rice, pulse (dhal), vegetables, fruit, and cocoanuts. There are Hindus who take no animal food except milk and ghee; but others take eggs, fish, and game while they refuse beef and pork. The Sikhs eat mutton and goat-flesh. The Hindus of the Punjab eat no meat, but the Mohammedans of the same region do, although they eat less than the European residents, and their prolonged fasts may assist their organs to recover from any ill-effects. Simpson[1] says the European residents would do well to copy the example of the Aryans. "When the Aryans descended into the plains of India they were meat-eaters, but experience taught them to be vegetarians or sparing in the consumption of animal food, and to refuse alcohol. . . . Europeans accustomed to live well in their own country, where large quantities of meat, wine, and spirits form an important part of the diet, are tempted to continue a similar diet in the tropics. Some do well on it, but they are exceptions. The majority who persist in high living in the tropics pay for it, sooner or later, in intestinal disorders, colitis, disease of the liver, or nervous disorder. . . . The history of the British occupation of India is full of sickness and death from want of adjustment of the diet to the new conditions. . . . It is recorded that the life of a regiment formerly was five years. There was no attempt to adjust the mode of life to the conditions. But a gradual improvement in the diet has effected a change in the health and mortality of Europeans. This consists of a general tendency towards a modified vegetarianism."

It has been observed that Europeans born and bred in the tropics have less desire for meat than full-grown people who arrive there. If they have any special craving, it is for sweet things. The large share which sugar takes in the diet of the tropical inhabitant is remarkable. Sweetmeats of every kind are used, and presents of sweetmeats and fruit are there equivalent to presents of game in colder climates.

Sir R. Havelock Charles[2] says it is impossible to form exact rules for dietary in the tropics because there are differences of climate which require modifications. He says nothing about limiting the amount of meat; but he says: "No *cold* meat whatever should come on the table; it is important that everything should come straight from the fire to the table. It cannot then cause bacilliary mischief, and there should be no fear of cholera or dysentery. Boiled water only should be drunk; no salads of any kind should be used except in the greatest moderation." As regards fruit, everything which possess a rind that can be removed may be eaten raw with impunity (provided it is peeled) by a healthy man at any time of the year. Fruits which do not possess a rind are incapable of being thoroughly cleansed; such fruit may be contaminated and dangerous to the consumer, and at any rate ought only to be

[1] *The Practitioner*, 1906, 585-592. [2] *Ibid.*, 1910, 13.

consumed after it is cooked. Therefore oranges, grape-fruit, pears, apples, bananas, mangoes, pineapple, custard-apples, mangosteen, tomatoes, etc., may be eaten raw after peeling them; but it would be unsafe to eat grapes, currants, strawberries, and other fruit which cannot be peeled, until they are cooked. In most places inhabited by Europeans, cabbage, cauliflower, kidney beans (snap or string beans), green peas, pumpkins, vegetable marrow (squash), and other vegetables are grown, and should be eaten fresh boiled. In some places green maize or Indian corn (*mealies*) are eaten after being boiled in milk or roasted in ashes; the boiled fruit of papan resembles a vegetable marrow; green bananas or plantains, boiled or roasted, also form an excellent vegetable. Potatoes are grown in many tropical places; but sweet potatoes, yams, taro, and cassava, when properly cooked, are a good substitute. As bread forms one of the chief sources of carbohydrate in the European dietary, it should still be consumed whenever it is obtainable; but there are many excellent substitutes, such as rice, maize, banana-meal, poie (from *Caladium esculentum*), manioc, sago, tapioca, vermicelli, macaroni, and biscuits. The various methods of cooking and utilizing these foods must be learnt from those who have lived long in such countries.

As regards proteins, some fish, fowl, or meat may be taken for breakfast; animal food ought not to be taken in the middle of the day, it is better to take dinner in the evening; beef, mutton, pork, kid (goat-flesh), venison (deer and antelope), poultry (many kinds of birds), eggs, and fish are obtainable in one place or another. Tinned meat and fish should be avoided as a general rule; indeed, the importance of *fresh* food is so great that hunting, shooting, and fishing should be strongly recommended as exercises. The flesh of native pig, deer, antelope, kid, birds, eggs, fish, turtle, and even molluscs, when fresh, is safer by far than tinned food. Other sources of protein are nuts (*e.g.*, pea-nuts), bean or pea-flour, banana-flour, and oatmeal, which, being eaten with milk, in the form of porridge or soup, forms a nutritious food.

Fat is obtained in the form of meat, dripping, butter, ghee, nuts, and various oils used in cooking. The pure oils from pea-nuts, palm-nuts, and cocoanuts are salutary; but many samples are adulterated with sesamé-oil, poppy-seed oil, and colza-oil, which are deleterious by causing dyspepsia or other gastro-intestinal troubles, which in turn render the subject susceptible to dysentery, sprue, and other tropical disorders.

As regards drink, unboiled water should never be taken; boiled water can be made palatable by fruit-juices, etc. Soda-water should be suspected; it is better to do without it unless it is quite above suspicion. Alcohol is absolutely unnecessary. Sir R. Havelock Charles says: "My own conviction is alcohol is unnecessary; if taken at all, it should be as a luxury. . . . Let a boy be an abstainer until he is thirty years of age, when he can use his own discretion." It is admitted by all authorities that the use of alcohol

in the tropics is a matter requiring grave consideration, and that men are better in health and can perform their duties without more satisfactorily than with it. Mohammedanism is against its use, and is backed up by science. Spirits are very deleterious unless freely diluted. Wine and beer ought to be drunk in moderation; about half a pint of red wine or one pint of beer daily is considered a fair allowance, and even that is better replaced by tea, coffee, cocoa, or their substitutes—caffer tea, Dorn-thé, goora-nut, kola, kât, moté, guarana, and other native beverages. The native alcoholic beverages are as injurious as European drinks. Saké in Japan, tar-asum in China, and chong in Thibet are prepared from rice, millet, and other grains. The sap of palmyra is drunk in its natural condition in India and Ceylon; but it is also fermented to make palm-wine, and a spirituous liquor called "toddy" is distilled from it. The milk of the cocoanut and sap of the tree are drunk unfermented wherever they grow; but they are fermented to form wine, and toddy is distilled from them. A spirit distilled from rice liquor is sold as *doasta* in Calcutta. According to Mann, it is 20 degrees under proof, but contains 0·56 per cent. of higher alcohols, or 491 grains per gallon. Shajehanjur rum, made from sugar refuse, is sold 53 to 56 degrees under proof. Mahua spirit is made from the flowers of *Bassia latifolia* in Bengal and Assam; it is sold 22 to 50 degrees under proof, and contains 0·004 to 0·33 per cent. of higher alcohols, which are very deleterious. Arrack is distilled from the sap of the palm-tree in India and Ceylon, and is frequently drugged with Indian hemp and other narcotics. The fruit of Carambola is used to make sherbet in India, and that of the sour gourd in Africa; the fruit of mangroves is also fermented in the East and West Indies. The juice of cacti is fermented wherever they grow. Pulque is the fermented juice of the agave or American aloe; it resembles cider, but has an odour of putrid meat; from it is distilled a spirit called "octli." In South America the juice of the cow-tree is used as a beverage; and in the West Indies another milky fluid is obtained from *Taberna montana utilis*. In Tartary the fermented mare's or ass's milk yields a spirit called *arika*; and in the Caucasus kephir is distilled to produce a spirit called *skhou*. There is no difference in the alcohol produced from these sources, and the higher alcohols which they contain are as deleterious as those in European spirits.

CHAPTER V

THE FEEDING OF INFANTS AND CHILDREN

In the preceding chapter the amount of food required by adults has been considered. It is now necessary to inquire into the amount required by infants and children, and to criticize the current methods of dieting them, and to make suggestions thereon.

The natural food of the mammalian animal before it is able to forage for itself is the milk of its own mother. The natural food of the human infant therefore is **human milk,** the average composition of which is—Protein 2·18, fat 3·62, lactose 5·79, salts 0·22, and water 88·19, per cent. But it varies considerably, the protein going from 0·85 to 4·86, fat 2·11 to 6·89, lactose 4·36 to 7·12, and the total solids from 9·57 to 13·12, per cent. These figures have been drawn from a careful consideration of the analyses given by sixteen authorities. At birth the capacity of the child's stomach is about an ounce, and during the first week it takes from 10 to 15 ounces daily. Tarnier found that from the fifth to the thirtieth day a child actually takes from 17 to 21 ounces (500 to 600 grammes), and from one to three months 21 to 28 ounces (600 to 800 grammes). These figures show that the amount of nutriment consumed varies as follows:

AMOUNT OF NUTRIMENT CONSUMED BY INFANTS.

Age.	Protein.	Fat.	Lactose.
	Grammes.	Grammes.	Grammes.
First week	6·15 to 9·22	10·28 to 15·37	16·41 to 24·60
Second and third weeks	9·22 ,, 18·44	15·37 ,, 30·74	24·60 ,, 29·20
Fourth and fifth weeks..	13·50 ,, 19·68	27·0 ,, 32·80	36·10 ,, 52·51
Sixth to twelfth week ..	14·70 ,, 22·14	24·6 ,, 36·90	39·3 ,, 59·27
Three to six months ..	17·20 ,, 23·37	28·7 ,, 38·95	45·9 ,, 62·35

A considerable proportion of women, for various reasons, are unable to suckle their young. Some substitute must be found from birth for the mother's milk. This may consist of the milk of the cow, goat, sheep, or other animal. **Goats** are frequently kept for feeding children. They are not subject to tuberculosis, and are easily tended and kept clean. Their milk is somewhat richer in protein and fat than human milk; but when mixed with ⅓ to ½ parts

of a 6 per cent. of lactose solution, made with boiled water, it is nearer to human milk in composition. **Cow's milk** is more often used because it may always be obtained. There is considerable difference in the composition of cow's milk and human milk. Human milk contains 1 to 3 per cent. of casein, and 0·25 to 1·0 per cent. of lactalbumin and lactoglobulin; cow's milk only contains 0·5 per cent. of lactalbumin and about 3½ per cent. of casein, which is not digested so easily. To bring cow's milk nearer to human milk in composition and to adapt it to the requirements of infants, it is usual to dilute it, and add some sugar and lime-water or barley-water. The table on p. 159 is given by Rotch[1] to show the requirements of infants.

It is obvious that merely diluting cow's milk with water will not secure the percentages recommended by Rotch; but the following mixtures of milk, sugar, and water are stated by Holt to have the composition annexed to them:

HOLT'S PLAIN MILK MIXTURES.

Proportions.	Composition of Mixture.		
	Protein.	Sugar.	Fat.
	Per Cent.	Per Cent.	Per Cent.
1. Milk-sugar 1 ounce, lime-water 1 ounce; boiled water to 20 ounces, added to milk 5 ounces	0·87	6·00	1·00
2. Milk-sugar 1 ounce, lime-water 1 ounce; boiled water to 20 ounces, added to milk 6 ounces	1·00	6·00	1·20
3. Milk-sugar 1 ounce, lime-water 1 ounce; boiled water to 20 ounces, added to milk 8 ounces	1·40	6·50	1·60
4. Milk-sugar 1 ounce, lime-water 1 ounce; boiled water to 20 ounces, added to milk 10 ounces	1·75	7·00	2·00
5. Milk-sugar ½ ounce, lime-water 1 ounce; boiled water to 20 ounces, plus milk 12 ounces	2·10	5·00	2·40
6. Milk-sugar ½ ounce, lime-water 1 ounce; boiled water to 20 ounces, plus milk 14 ounces	2·50	5·50	2·80
7. Milk-sugar ½ ounce, lime-water 1 ounce; boiled water to 20 ounces, plus milk 16 ounces	2·80	5·50	3·20

The casein of cow's milk coagulates in large heavy masses, very different from the light flocculent precipitate of human milk; it requires longer time and a greater expenditure of energy for digestion than human milk. But the formation of large coagula can

[1] *Archives of Pediatrics*, February, 1893.

THE DAILY REQUIREMENTS OF INFANTS.

Age of Child.	Nutrients in Food per Cent.			Total Quantity.	Quantity per Meal.	Number of Meals.	Intervals.
	Protein.	Sugar.	Fat.				
				Ounces.	Ounces.		Hours.
Premature infants	·25	4·00	1·00	3 to 10	¼ to ¾	12 to 18	1 to 1½
First to fourth day	·30	5·00	1·00	10 ,, 15	1 ,, 1½	6 ,, 10	2 ,, 4
Fifth to seventh day ..	·50	5·00	1·50	10 ,, 20	1 ,, 2	10	2
Second week	·60	6·00	2·00	20 ,, 25	2 ,, 2½	10	2
Third week	·80	6·00	2·50	20 ,, 35	2 ,, 3½	10	2
Fourth to eighth week ..	1·00	6·00	3·00	25 ,, 36	2½ ,, 4	9	2½
Third month	1·25	6·00	3·00	25 ,, 40	3 ,, 5	8	2½
Fourth month	1·50	7·00	3·50	28 ,, 42	3½ ,, 5½	7	3
Fifth month	1·75	7·00	3·50	28 ,, 42	4 ,, 6	7	3
Sixth to tenth month ..	2·00	7·00	4·00	30 ,, 48	5 ,, 8	6	3
Eleventh month	2·50	5·00	4·00	30 ,, 48	6 ,, 9	5	4
Twelfth month	3·00	5·00	4·00	35 ,, 48	7 ,, 9	5	4
Thirteenth month	3·50	4·50	4·00	35 ,, 50	7 ,, 10	5	4

BIEDERT'S CREAM MIXTURES.

Age of Child.	Cream.	Solution of Lactose (6 per Cent.).	Cow's Milk.	Total Quantity.	Composition per Cent.			Calories per Ounce.
					Protein.	Fat.	Sugar.	
	Ounces.	Ounces.	Ounces.	Ounces.				
1. First month	5	15	nil	20	1·0	2·5	5·0	13·0
2. Second month	5	15	2½	22½	1·4	2·6	5·0	13·3
3. Third month	5	15	5	25	1·5	2·6	5·0	15·3
4. Fourth month	5	15	10	30	1·8	2·8	5·0	16·1
5. Fifth month	5	10	20	35	2·1	3·0	5·0	18·0
6. Sixth month	5	10	25	40	2·3	2·4	5·0	16·0

be prevented by the addition of lime-water, barley-water, dextrin, extract of malt, and citrate of soda. The use of these materials for the purpose indicated is quite common.

When **cream** is diluted with water and acidulated, the protein is coagulated in fine feathery flocculi much nearer in character to the coagula of human milk than the masses of casein from a mixture of milk and water. This has led to the use of cream and top-milk in the mixtures for feeding infants. Gravity cream, obtained by skimming the milk after it has been set aside for eight to twelve hours, is preferable to centrifugal or commercial cream for this purpose. In gravity cream the fat remains in a fine state of division, there being one and a half million globules in a single drop; but in centrifugal cream the emulsion is broken down, and the fat is in large conglomerate masses. Biedert declared that the essential faults of cow's milk as an infant's food could be eliminated by using gravity cream obtained by the usual domestic method. Such cream usually has the following composition: Fat 10, protein 3·6, sugar 4·5, per cent. He arranged the mixtures given in table on p. 159, and stated that they have the composition annexed to them.

Gaertner's fat milk is an excellent substitute for cream mixtures, and is prepared as follows: Dilute 1 pint of milk with 1 pint of water, and add 1 ounce of lactose. Raise the temperature of the mixture to 97° F. and centrifugalize it; pour the creamy half into a vessel and cool it. It has the following composition: Protein 1·5 to 2·0, fat 3·25, sugar 6·0, ash 0·37, per cent. A simpler method is to put the milk into a glass barrel, with a tap; allow it to stand four hours, when practically all the fat will be in the upper half. Turn on the tap, and allow the bottom half to flow out. Replace the quantity drawn off by the addition of barley-water or plain boiled water, the requisite amount of sugar of milk, and a few grains of common salt.

HOLT'S TOP-MILK MIXTURES.

Proportions.	Add 7 per Cent. Milk.	Composition of the Mixture.		
		Fat.	Sugar.	Protein.
	Ounces.	Per Cent.	Per Cent.	Per Cent.
1. Milk-sugar 1 ounce, lime-water 1 ounce, boiled plain water to 20 ounces	3	1·00	5·50	0·50
2 Ditto	4	1·40	5·75	0·70
3. Ditto	5	1·75	6·00	0·85
4. Ditto	6	2·10	6·00	1·05
5. Ditto	7	2·50	6·50	1·25
6. Ditto	8	2·80	6·50	1·40
7. Ditto	9	3·15	7·00	1·55
8. Ditto	10	3·50	7·00	1·75
9. Ditto	12	4·00	7·00	2·00

Top-Milk Mixtures.—When a quart of milk has been standing for eight hours, nearly all the fat is in the cream; it is estimated that the upper 4 ounces would contain 21 per cent. of fat, and is excellent cream; the upper 6 ounces 16 per cent., 8 ounces 13 per cent., 11 ounces 10 per cent., and 16 ounces 7 per cent., of fat. The latter is called *7 per cent. milk*, and has the following composition: Fat 7·0, sugar 4·40, and protein 3·50, per cent.; with it Holt[1] makes the mixtures given in table on p. 160.

If 10 per cent. milk is used, only 2 ounces should be added to make No. 1, and 3 ounces for No. 2; 4 ounces would make No. 3, containing not quite so much protein. Winter, of Cornell University, has also arranged a series of top-milk mixtures composed of the same ingredients. Biedert, observing the variable composition of cream obtained by skimming, and the difficulty of obtaining it free from undesirable micro-organisms, caused a preparation, which he called Ramogen, said to be made from goat's milk, to be put up in tins. It is standardized to contain—Fat 15, protein 7, milk-sugar 10, cane-sugar 25, per cent. When diluted with water, the mixture has the following composition:

RAMOGEN AND WATER: COMPOSITION.

Parts of Ramogen to Water.	Protein.	Fat.	Sugar.	Calories per 1,000 c.c.
	Per Cent.	Per Cent.	Per Cent.	
1 to 6	1·0	2·2	5·1	450
1 ,, 5	1·2	2·6	5·9	590
1 ,, 4	1·4	3·2	7·1	650

Sweetened Condensed Milk has an average composition of protein 10·0, fat 10·5, and sugar 51·5, per cent. The following mixtures, made according to the directions of a well-known firm of makers, have the composition annexed to them:

CONDENSED-MILK MIXTURES.

Age of Child.	Parts of Condensed Milk to Water.	Protein.	Fat.	Sugar.
		Per Cent.	Per Cent.	Per Cent.
One to seven days	1 to 16	0·625	0·667	3·28
Two to eight weeks	1 ,, 12	0·833	·875	4·29
Three to four months	1 ,, 10	1·00	1·05	5·15
Over four months	1 ,, 8	1·25	1·312	6·43
Or	1 ,, 7	1·45	1·50	7·36

These mixtures do not form a well-balanced diet for infants, as may be seen by comparison of the requirements given in a previous table by Rotch.

[1] "Diseases of Children."

Extract of Malt is a useful carbohydrate for sweetening cow's-milk mixtures instead of lactose. Its composition is about the following: Protein 6·0, maltose 45·0, dextrin 7·2, invert sugar 14·5, cane-sugar 3·4, per cent. It has a beneficial influence over casein, causing it to be coagulated in fine flocculi, which are digested much more easily than the large masses of casein coagulated without its influence. The following mixtures have a proper composition for infants of the ages given:

EXTRACT OF MALT AND MILK MIXTURES.

Age.	Water.	Cream.	Milk.	Extract of Malt.
	Ounces.	Ounces.	Ounces.	Ounces.
Birth to one month	14	2	6	1
One to three months	12	2	8	1
Three to six months	10	2	10	1
Six to nine months	6	1	14	1

Mix the cream and extract of malt together in a warm vessel, stir in the milk and water at a temperature of 130° to 140° F., and let it stand ten or fifteen minutes. Where cream cannot be obtained, ½ ounce of butter may be used instead of it, taking care that it is thoroughly mixed with the extract of malt before adding the milk and water.

Artificial Foods for infants are very numerous. The composition of many is given in my book—"Foods: their Origin, Manufacture and Composition." They are, of course, not so suitable for the infant as human milk. But when this is deficient or unobtainable, many of them are better than improperly prepared milk mixtures. Young infants cannot digest starch, and therefore the preparation adopted ought to be as free as possible from it. The foods of Allenbury, Mellin, Horlick, are among the best of these. Several others are self-digesting, as Benger's. When the child is a few months old, it may have such foods as contain the higher dextrins (approaching to maltose), and later on those having lower dextrins (approaching to starch). Malted foods are preferable to unmalted cereal preparations; the diastase converts the starch into dextrins, maltose, iso-maltose, and a little dextrose. Savory and Moore's is such a food, and there are many others. When the child is over six months old, some **oatmeal** may be given. Chalmers Watson and Fordyce made experiments showing that it stimulates growth by its action on the thyroid gland, and concluded that oatmeal and milk is a better food than bread and milk.

There are various circumstances requiring a modification of the diet. In all cases the physician should give very careful and definite instructions for feeding the infants under his care. In spite of such care various disturbances of the alimentary canal and general health may arise; how much more, then, are they likely to arise when scrupulous care is not exercised! In all cases of digestive

disturbance, and especially when the condition is acute, there should be an immediate reduction of all the constituents of the food—that is to say, the child must have less food. But the particular ailment may require the reduction of only the protein, the fat, or the carbohydrate. Vomiting is frequently due to an excess of casein in the form of hard curds; pain may be due to the same cause; spasm of the pylorus may be caused by such masses of casein. When these symptoms arise, the character of the vomit should be examined, and the food modified accordingly. If the infant is breast-fed, the regular increase in weight ought to show that he is getting enough. If he is not getting enough food this way, the weight-chart will not show a satisfactory rise week by week. The mother's milk should be supplemented in such a case by the cream or top-milk mixtures given above. The use of **barley-water** to prevent the formation of heavy curd from cow's milk has long experience to recommend it. It is made by boiling pearl-barley until the liquid, after straining and cooling, sets into a thin jelly; it contains 1·25 per cent. of solid matters, including about 0·117 per cent. nitrogenous, 1·078 per cent. dextrin, 0·02 per cent. fat, and 0·035 per cent. mineral, matters. When it is prepared from barley-flour, the decoction must of necessity contain some starch, but the longer it is cooked the more starch will be dextrinized. The use of prepared or artificial foods has to be considered in such cases; those consisting of dried milk and malted or dextrinized cereals are the best.

The kind of sugar in infant's foods may have to be considered. Lactic acid is essential for gastric digestion in infants. But the glands may secrete too much, and cause the vomited substances to be excessively acid. Acid fermentation in the alimentary canal results in the destruction of peptones and lactose. Therefore it may be necessary to use some other sugar than lactose in artificial feeding. Cane-sugar and maltose pass through the stomach unaffected by lactic acid ferments, and should be used when too much acidity arises.

Infants frequently excrete an undue amount of ammonia in their urine. It is a consequence of acidosis or acid intoxication, as a defect in the metabolism of fat or protein. Czerny and Kellner found it arose from an excess of fat in the food, or an inability on the part of the child to properly digest it. In such cases it is advisable to reduce temporarily the amount of fat.

When the digestive trouble arises from excess of curd, the casein must be reduced. The proteins of cow's milk are casein and albumin in the proportion of 100 to 14; in human milk the proportion is 100 to 50. But casein can be modified as suggested in the cream and top-milk mixtures, or the extract of malt mixtures. Sometimes it is necessary to exclude casein altogether for a few days. We may then make use of albulactin or other preparations of lactalbumin. In cases of zymotic diarrhœa, the use of albumin-water is better than any other means of feeding: the white of an egg is beaten up and added to 6 ounces of boiled water, a little

cream, lactose, and common salt. In other cases again peptonized milk, Benger's food, peptogenic milk-powder, etc., may be usefully employed. In cases of fat-diarrhœa, whey or butter milk are good foods.

Infants fed on cow's-milk mixtures absorb much water and excrete much urine, and some of them frequently cry from hunger. When these features are very marked, an attempt may be made to feed the child with *undiluted cow's milk.* Budin, of Paris, had considerable success with this mode of feeding from birth onwards, and found children fed in this way "have no tumid abdomen, no milk dyspepsia, no scurvy, no rickets, no tuberculosis, no weakness, and no flabbiness."

After six months of age undiluted cow's milk is one of the best foods. But it is not a well-balanced food, as it contains too much protein and too little carbohydrate. The average composition of many thousands samples of milk analyzed is—Protein 3·73, fat 4·07, sugar 4·45, per cent. Now, according to Rotch's table given above, a child from six to ten months requires a food having the following composition: Protein 2·00, fat 4·00, sugar 7·00, per cent., or a daily supply of protein 18 to 27, fat 36 to 54, carbohydrate 63 to 105, grammes.

At six months 1¾ pints of milk, and at nine months 2½ pints is usually considered a fair allowance; they contain the following:

1¾ pints of milk contain—Protein 37·3, fat 40·07, sugar 44·45, grammes.
2½ ,, ,, ,, ,, 52·0, ,, 57·00, ,, 62·00, ,,

There is a decided excess of protein and fat in these quantities, while the carbohydrate is too little. We can trust, however, to the infant's organism effectively splitting some of the excess of protein into fat and urea, and some of the excess will be used for tissue-building. It is not advisable to keep to a hard-and-fast rule, but we must add some carbohydrate. The proprietors of an infant's food recommend that *a child of nine to twelve months* should have as follows:

7 *a.m.*—Prepared food with 10 ounces of cow's milk.
10 *a.m.*—Biscuit or rusk with 10 ounces of cow's milk.
1.30 *p.m.*—A raw egg with 10 ounces of cow's milk.
5.30 *p.m.*—Prepared food, slice of stale bread, with 10 ounces of cow's milk.
10 *p.m.*—Prepared food and 10 ounces of cow's milk.

The entire food would contain 68 grammes protein, 58 grammes fat, and 172 grammes of carbohydrate, and errs on the side of generosity even for a child of nine months old.

At two years of age a child requires food containing 2 grammes of protein, 4·5 grammes of fat, and 8·0 grammes of carbohydrate per kilo of body-weight, or half these quantities per pound; and a total of 28·0 grammes of protein, 63 grammes of fat, and 112 grammes of carbohydrate to meet its expenditure. This would be amply met by the following items: Milk 1 pint, farinaceous food 2½ ounces, one egg, meat-broth 5½ ounces, milk pudding 1¾ ounces, bread

2 ounces, butter or fat ½ ounce, the contents of which would approximate to—Protein 50, fat 50, carbohydrate 115, grammes daily.

After the period of infancy the diet may be governed by the rule of Atwater, from which the following standard is devised:

FOOD OF CHILDREN AFTER THE PERIOD OF INFANCY.

Age.	Average Weight.	Protein.	Energy.
	Pounds.	Grammes.	Calories.
Child, two to five years, requires 0·4 food of man	35	42	1,400
Child, six to nine years, requires 0·5 food of man	55	53	1,750
Boy, eleven to twelve years, requires 0·6 food of man	67	63	2,100
Boy, twelve years, requires 0·7 food of man..	78	74	2,450
Boy, thirteen to fourteen years, requires 0·8 food of man	85	84	2,800
Boy, fifteen to sixteen years, requires 0·9 food of man	117	95	3,150
Girls, ten to twelve years, requires 0·6 food of man	69	63	2,100
Girls, thirteen to fourteen years, requires 0·7 food of man	89	74	2,450
Girls, fifteen to sixteen years, require 0·8 food of man	111	84	2,800

A child of three years would be well fed when consuming milk 1 pint, farinaceous food 2⅓ ounces, one egg, meat 1 ounce, oatmeal ½ ounce, sugar 1 ounce, bread 3 ounces, butter ½ ounce, and some vegetable or fruit. This diet would contain 53 grammes of protein, 50 grammes of fat, and 155 grammes of carbohydrate, yielding about 1,250 calories. Any addition to it might be in the form of bread-and-butter.

When children arrive at three years of age, they are usually fed with the same food as adults—that is, with anything on the table. This principle is not scientific. The food for the next few years should be selected from a list such as the following: Bread, oatmeal, potatoes; milk, cream, milk-puddings; meat, varying in amount according to age, such as tender beef, mutton, chicken, rabbit; the lighter kinds of fish; eggs, boiled or poached; broth in which vegetables have been boiled; boiled tender vegetables; cooked apples, rhubarb, strawberries, plums (free from skin), prunes; uncooked fruit, such as oranges, strawberries, apples, bananas. Children require plenty to drink, which may consist of milk, milk and water, and plain or distilled water; weak tea or cocoa may be allowed after four or five years of age.

The food should not be monotonous; frequent changes are salutary. Bread should be light and porous, one day old; new bread or cakes should be eschewed. Sweet cakes and rich puddings upset the alimentary functions and cause "night terrors." Lean ham or bacon, corned beef, dried beef, pork, veal, liver, kidneys, goose, duck, and the dressings (forcemeat) from such foods, ought

not to be given to children. Heavy vegetables, such as turnips, ruta-baga, Jerusalem artichokes, dried peas or beans, celery, radishes, and cucumber, should not be allowed to young children. Erroneous ideas prevail as to the amount of meat required by children; nurses and mothers seldom give them enough. It is absolutely essential for them to have plenty of protein to supply the materials for growth; an abundance of fat and carbohydrate are equally necessary to supply the carbon oxidized in their great metabolic activity. The following table by Sommerfield shows the amount of food required at various ages:

Age.	Protein.	Fat.	Carbohydrates.	Energy.
	Grammes.	Grammes.	Grammes.	Calories.
Two to four	40 to 64	32 to 42	110 to 200	912 to 1,483
Five to seven	50 ,, 58	30 ,, 43	145 ,, 200	1,078 ,, 1,448
Eight to ten	60 ,, 80	30 ,, 70	220 ,, 250	1,427 ,, 2,000
Eleven to twelve ..	68 ,, 86	44 ,, 85	210 ,, 270	1,549 ,, 2,252
Thirteen to fifteen ..	72 ,, 86	45 ,, 85	245 ,, 270	1,720 ,, 2,252

If a sufficiency of protein is given to a healthy child, we may safely leave the amount of other items to them. Children digest quickly; their respiratory activity is very great even when the body is at rest. For these reasons the supply of bread-and-butter, or other fat, jam, marmalade, syrup, or honey, should be unlimited, leaving if possible their appetite alone as a safe guide to their bodily requirements.

Food in Sickness.—Many observations on the metabolism in sick children were made by Baginsky. For dietetic purposes he divided them into the following groups: (1) Convalescents from severe illness, afebrile diseases, chronic diseases in which over-nutrition is desirable; (2) diseases in which there is a moderate rise of temperature, and the beginning of convalescence; (3) febrile diseases in which liquid food is necessary. His observations led him to formulate the following requirements:

REQUIREMENTS DURING SICKNESS.

Age.	Disease.	Protein.	Fat.	Carbohydrates.	Energy.
		Grammes.	Grammes.	Grammes.	Calories.
Two to four years	Group 1.	51·3	51	149	1,307
,, ,, ,, ...	,, 2.	43·5	44	115	1,060
,, ,, ,, ...	,, 3.	42·0	45	49	790
Five to eight years ..	,, 1.	70·0	61	221	1,571
,, ,, ,, ..	,, 2.	76·0	99	244	2,130
,, ,, ,, ..	,, 3.	53·0	58	69	1,040
Nine to fourteen years ..	,, 1.	85·5	82	271	2,225
,, ,, ,, ..	,, 2.	81·0	85	250	2,213
,, ,, ,, ..	,, 3.	69·3	73	95	1,350

The only disagreement we find with this table is with the small amount of carbohydrate. The tissues are rapidly wasted in febrile

diseases, and it is rational to make use of the protecting influence of carbohydrate, especially sugar, to check this waste as much as possible. Let us see how far the dietaries of children's hospitals agree with his chart.

1. *Milk Diet* contains 2 pints of milk, 6 ounces of bread, 1 ounce of butter, 3½ ounces of rice pudding; the equivalent of 60·8 grammes of protein, 80 grammes of fat, 160 grammes of carbohydrate, and 1,162 calories of energy. It is sufficient for a child of two to five years in Group 1; if the bread is boiled in the milk, it would do for any child over eighteen months old.

2. *Broth Diet* includes ½ pint of mutton broth, 1¼ pints of milk, 7½ ounces of bread, 1 ounce of butter, and is equivalent to 62 grammes of protein, 55 grammes of fat, 138 grammes of carbohydrate, and 1,344 calories. It is suitable for a child of four or five years, or even up to eight years, in Group 3, and with a smaller amount of bread for younger children.

3. *Beef-Tea Diet* contains 13 ounces of beef-tea, 1½ pints of milk, 5 ounces of bread, 1 ounce of butter, and includes 67 grammes of protein, 60 grammes of fat, 112 grammes of carbohydrate, and 1,296 calories.

4. *Fish Diet* contains 2½ ounces sole, plaice, or other white fish, 3⅓ ounces of potato, bread 8 ounces, butter 1 ounce, or treacle 2 ounces, milk 1 pint (or milk ½ pint and cocoa ½ pint). It contains 50 grammes of protein, 50 grammes of fat, and 204 grammes of of carbohydrate, yielding 1,534 calories. It is suitable for the beginning of convalescence in children from five to twelve.

5. *Meat Diet* contains 2½ ounces of meat, 4 ounces of potato, 6½ ounces of bread, 1½ ounces of butter or dripping, and 1 pint of milk (or ½ pint of milk and ½ pint of cocoa). The contents are 58 grammes of protein, 73 grammes of fat, 178 grammes of carbohydrate, and 1,645 calories. It is suitable for children during convalescence or chronic diseases up to nine years of age. For calculating other dietaries the following figures may be used:

NUTRIENTS IN VARIOUS FOODS.

Substance.	Protein.	Fat.	Carbo-hydrate.	Energy.
	Grammes.	Grammes.	Grammes.	Calories.
1 pint of milk	21·15	23·08	25·23	405
1 ounce cooked beef	7·5	4·5	—	71
1 ounce cooked mutton	7·8	7·0	—	97
1 ounce cooked fowl	8·4	3·5	—	67
1 ounce cooked codfish	8·3	0·15	—	35
1 cooked egg	6·7	5·8	—	80
4 ounces of bread	10·0	1·0	56·4	282
1 ounce of oatmeal	4·4	3·0	17·8	119
1 ounce of butter	—	24·0	—	223
1 ounce of sugar	—	—	27·0	110
2 ounces of boiled potato	1·42	0·06	11·9	55
2 ounces of rice pudding	1·13	1·33	9·1	54

CHAPTER VI

THE FOOD IN OLD AGE

YOUTH is the period of transition from infancy to maturity, old age of transition from maturity to decay. In early life the physiological powers are directed to building up the organism and the development of its different functions. An abundant supply of food is required for these operations; the intake of food exceeds the amount of the excreta, the supply exceeds the losses, and the body increases in size. In this active period the worn-out cells are regenerated easily and quickly; the growth of new cells exceeds the decay of effete ones. In the course of time, however, the processes of decay and reparation are exactly balanced; the body ceases to grow in size: it has reached maturity. In the normal condition of things this balance is maintained for many years. But ultimately a period arrives when the balance begins to incline; the powers of the system are unequal to the demands upon them; the activity of the cellular elements diminishes; the renovation of decayed cells is not so rapid; there is a diminution in bodily energy; the waste of the body exceeds the supply. In proportion, however, as physiological renovation is less active, Nature economizes the use of material, the resources of the system are husbanded with greater care, and the functions appear to go on for a long time without apparent alteration. Nevertheless, changes are going on which are insidious but no less real. Old age comes upon us by slow and imperceptible degrees, and Nature kindly smooths the path along which we descend, and conducts us by easy stages to our destined place of repose.

Although the powers of the constitution become enfeebled by age, and the physiological functions are less vigorously performed, yet, if the body be in a healthy condition, they must be considered as normally fulfilling the designs of Nature in the later stages of existence. There is, however, a material difference between the health of youth and the health of old age. In the former the vitality is greater, the recuperative powers more efficient; the organism rebounds with surprising elasticity from the depression of a severe illness. In the latter vitality is more feeble, the constitution is not so resilient, the spring no longer reacts with a force equal to that with which it is extended; the recuperative power is deficient; the body is incapable of doing the same amount of work. Slight deviations from the normal performance of function occur, which may, however, for a long time be imperceptible. But

gradually these increase in extent until they become manifest indications of a failure of the bodily powers or of disordered health. Excitement or exertion, formerly harmless, is not so well borne Slight causes are followed by effects somewhat out of proportion to the cause; exhaustion is out of proportion to the work performed; a chill produces serious effects. Among the numerous indications of a wavering metabolic balance and disturbance of the functions incident to the decline of life are symptoms of disorder in the alimentary system. The principal of these is undoubtedly the gradual decline of muscular power which pervades the whole system. In this decline the muscular fibres of the stomach and bowels must necessarily participate. But it often happens that while the powers of digestion and assimilation diminish, the appetite remains good, and consequently more food is consumed than can be digested and absorbed. The unabsorbed portion tends to undergo fermentation, to produce distension of the stomach and bowels by flatus, to cause irritation by the production of acids and toxins, to give rise to hypertonus of the bloodvessels, to lay the foundations of a vitiated habit, and of permanent injury to the tone of various organs. There is frequently a change in the action of the bowels; some of those people who were subject to constipation in adult life become loose, and *vice versa*. In the one case this is owing to irritation by undigested food, and the other to sluggishness in the peristaltic action of the bowels. The heart partakes of the same or similar changes; the muscular tone of the organ becomes lowered, in some cases leading to cardiac dilatation, hypotonus of the bloodvessels, to hepatic hyperæmia, and catarrh of the stomach and bowels from venous congestion. In other cases the muscular tone of the heart is perhaps exaggerated, owing to hypertonus of the bloodvessels, to atheroma, calcification, or other changes therein, in consequence of which the cardiac muscle becomes hypertrophied to overcome the increased resistance to the circulating fluids. The failure of energy also shows itself by an alteration of the cerebral faculties, by increasing listlessness and lethargy, heaviness and somnolence, failure of mental power, confusion of thought, and loss of memory.

The pathological changes incident to age have been summed up by Metchnikoff as a sclerosis which may affect the brain, liver, kidneys, and other organs, but is mostly seen in the bloodvessels. The bones grow thin and brittle with advancing age, the tissues atrophy and become replaced by hypertrophied connective tissue, especially visible in the arteries. In the brain and nerves, the cells which perform motor, sensory, and intellectual functions give place to lower or neuroglia cells. The liver cells recede before the invasion of connective-tissue cells. A similar condition takes place in the kidneys and other organs. In short, old age is a struggle between the proper functional cells of the organs and the simple connective-tissue elements, and the latter are the conquerors. Phagocytes, too, aid in the process, as is seen in the whitening of the hair. Normal hair is full of pigment, but at a certain period the cells of the medulla

become active, and devour the pigment granules within reach, and so the hair, robbed of colour, gives the first manifestation of age. The increasing porosity of the bones is likewise due to the absorption of the osseous lamellæ by phagocytes.

All these variations and changes lead to a consideration in the minds of those who have most carefully watched the progressive deterioration of the organism in old age, whether something cannot be done to strengthen the most valuable cellular elements on the one hand, and weaken the phagocytes on the other. But the problem is not yet solved. It is our place to consider the amount and quality of the food which should be consumed. It is generally recognized that the food requirements are varied by age, sex, occupation, and other circumstances of the individual. The influence of many of these circumstances upon food requirement has already been considered. It now remains to be seen to what extent the food requires modification in old age. The subject has been considered by many writers from the early ages downwards.

Celsus, in the first book "De re Medica," gives excellent advice regarding food and exercise for the strong and weak applicable to the aged. He says it behoves a person to pass a diversified kind of life; indolence enervates, labour strengthens the body; the former brings on premature old age, the latter produces a prolonged period of youth. Exercise should precede a meal, stronger in him who has laboured, more gentle in him who is fatigued. He advises his subject to avoid no kind of food which people use; to take food twice a day, provided he can digest it. Bodies which are high fed speedily grow old and fall sick. Too much overloading of the stomach is never proper, too much abstinence is injurious; if there is any intemperance it is safer in drink than in food. All seasoned things are injurious. Moderation is the keynote of his recommendations.

Cornaro, an Italian, published a treatise on "Temperance and Sobrietie" in 1558, wherein he states that after living a life of excesses of all kinds he became every ill, and as a consequence of advice, began to observe great moderation in eating, drinking, and other things. He gave up his former excesses, regained his health, and in consequence of regularity and careful feeding lived to a great age. He did not state the amount of food he consumed daily, but he so clearly recognized that the food requirements diminish as a person grows old, that it is fair to presume that he arranged his dietary in accordance with his views. In one of his essays he says that as he advanced in years and lost vigour, he felt that he ought to lessen rather than increase the amount of his food. He appears to have taken everything which agreed with him, and nothing which did not. He states that, when seventy-eight or seventy-nine years of age, his daily diet consisted of 12 ounces of bread, with meat, yolk of eggs, meat-broth, and 12 ounces of wine.[1]

[1] A diet of 12 ounces bread, 3 egg yolks, $3\frac{1}{2}$ ounces of meat, and 12 ounces of wine, would contain about 65 grammes of protein and yield 1,360 calories. The bulk of the food is small, and the amount of animal substance would not be considered large.

He does not say if these are the amounts he consumed in the earlier period (sixty-five to seventy-five years). When he was eighty-six years of age he mentions bread, porridge, broth, eggs, veal, mutton, kid, poultry, wild birds, and fish, among the articles which he consumed. He paid great attention to exercise in the open air, to the hours of sleep, to wholesome pleasures, and all other things which are important to the maintenance of health.

Lescius, who wrote in 1634 on the "Right Course of Preserving Life and Health unto Extreme Old Age," held similar views on the requirements of food in later life. He states that the amount of food required is largely determined by labour, and as old people do less work than in early adult or middle life, they require less food. In his opinion the daily food of aged persons should not exceed 12 or 14 ounces, and should consist of bread, meat, eggs, and similar foods.

Boerhaave, in his aphorisms on the knowledge and cure of diseases, constantly recommended moderation when writing of aged persons. Indeed, moderation is the keynote of all the ancient authorities when writing of aged people.

Among more recent writers, Voit,[1] who bases his observations on investigations made by Forster, considered that the conditions of old age indicate a ration of 0·8 the value of that for men and women of mature age, in good health, and doing moderate work. In other words, the food should contain—

Voit's Dietary Standard for Aged Persons.

	Protein.	Energy.
	Grammes.	Calories.
Old man, no work	90	2,116
,, ,, light work	100	2,689
Old woman, no work	80	1,831
,, ,, light work	85	2,096

In this standard, however, no age is stated, and the amount of protein is considered by some authorities too great. Apart from theoretical considerations, it is a fact that as age advances and bodily exercise diminishes, the standard of food requirement also diminishes. This fact is recognized by Maurel,[2] who states that as age increases the amount of external muscular work performed is smaller, the internal muscular work is decreased, and consequently the nutritive requirements per kilogramme of body is correspondingly decreased. He made valuable observations from his own clinical experience and the experiments of others, from which he concluded that bodily requirement decreases progressively. Thus he estimated that a healthy man or woman in middle life requires 1·5 grammes of protein and 35 to 38 calories of energy

[1] *Zeit. f. Biol.*, 1876, 32. [2] *Rev. Soc. Sci. Hyg. Aliment*, 1906, 763.

per kilogramme of body-weight, to maintain the organism in equilibrium when no work is being performed, and that any muscular work must be met by an increased supply of nutriment. From this estimate he framed the following maintenance ration for adults:

MAUREL'S MAINTENANCE RATION FOR ADULTS.

Sex.	Weight.		Protein.	Energy.
	Kilos.	Pounds.	Grammes.	Calories.
Man	70	154	105	2,450 to 2,660
Woman	60	132	90	2,110 ,, 2,280

He divides old age into several periods; the first period of decline being from fifty to seventy years, when he considers the body will be maintained in equilibrium by the supply, 1·25 grammes of protein and 30 to 35 calories of energy per kilo; in the second period of decline, seventy years and over, 1·0 gramme of protein and 25 to 30 calories; and in the third period, or extreme old age, the demand falls still more, 0·75 gramme of protein and 20 to 25 calories of energy will suffice. These may be tabulated as follows:

MAUREL'S MAINTENANCE RATIONS FOR OLD PEOPLE.

Age.	Protein per Kilo.	Energy per Kilo.
	Grammes.	Calories.
Adult	1·5	35 to 38
Fifty to seventy years	1·25	30 ,, 35
Seventy years and over	1·00	25 ,, 30
Extreme old age	0·75	20 ,, 25

Langworthy,[1] by using Maurel's maximum factors and taking the average weight of old men and women to be the same as found by Quatelet,[2] has framed the following table to show the estimated requirements of old men and women:

FOOD REQUIREMENTS OF OLD PEOPLE, BASED ON MAUREL'S AND QUATELET'S FIGURES.

Subjects.	Age.	Average Weight.		Protein required.	Energy required.
	Years.	Kilos.	Pounds.	Grammes.	Calories.
Men	60	65·50	144·1	81·9	1,965
,, ...	70	63·03	138·7	78·8	1,891
,, ...	80	61·22	134·7	45·9	1,531
,, ...	90	57·83	117·2	43·4	1,446
Women	60	56·73	124·8	70·9	1,702
,, ...	70	53·72	118·2	67·2	1,612
,, ...	80	51·52	113·3	38·6	1,288
,, ...	90	49·34	108·5	37·0	1,234

[1] Bulletin 223, U.S. Department of Agriculture.
[2] Landois and Stirling's "Human Physiology," 1891.

There is a considerable difference between the maintenance requirements according to Maurel and the amount considered necessary by Voit. It should be noted again, however, that Maurel's figures are for maintenance only and not for work, and when external muscular work has to be performed, provision has to be made for it by increasing the ration. Many old people, and even those who have to arrange dietaries for them, do not recognize the decrease in weight as a factor influencing the amount of food required. But bodily weight as well as bodily activity diminishes with increasing age, and these together reduce the actual requirement of food. On the other hand, people who are unable any longer to employ themselves in bodily occupations and pleasures often find enjoyment in ministering to the pleasures of the palate. This is not altogether profitable to them; all who have considered the subject find that the most long-lived subjects have rarely been big feeders, and especially so with regard to animal food. But many old people are really big eaters considering their inactivity. It would be well therefore to compare Maurel's estimate of requirements with the amount of food actually consumed by old people. Fenger[1] made a study of the food consumed by a woman, aged sixty-one years, which she chose herself, and which seemed enough for her. There were four diets:

	Protein.	Calories.
	Grammes.	
First diet contained	80	1,125
Second ,, ,, ...	85	1,200
Third ,, ,, ...	87	1,230
Fourth ,, ,, ...	84	1,600
Average ,, ...	84	1,289

The protein was ample, and contained 13 grammes more than is required for maintenance, according to Maurel, but 440 calories less.

Kosevi[2] found that the food consumed by women aged seventy-six and seventy-eight years contained—

	Protein.	Calories.
	Grammes.	
Woman, seventy-six years, 45 kilos: first diet ..	77	1,361
,, ,, ,, ,, ,, second diet ..	66	1,361
,, ,, ,, ,, ,, third diet ..	66	1,165
Woman, seventy-eight years, 61 kilos: first diet ..	41	1,275
,, ,, ,, ,, ,, second diet ..	41	1,575
,, ,, ,, ,, ,, third diet ..	67	1,207

[1] *Skand. Arch. Physiol.*, 1904, 222.
[2] *Centralb. f. Inn. Med.*, 1901, 121.

Von Limbeck[1] found the food of two women contained—

	Protein.	Calories.
	Grammes.	
Woman, seventy-nine years, 38 kilos: first diet ..	71	1,289
,, ,, ,, ,, ,, second diet ..	71	1,291
Woman, eighty-one years, 37 kilos: diet ..	77	1,361

In 1907 a study was made of the food consumed in a Home for Old Ladies in Philadelphia.[2] There were 113 women: 10 from sixty-five to seventy years old, 73 from seventy to eighty years old, 20 from eighty to ninety years old, and 10 from ninety to one hundred years old. *The amount of food supplied was unlimited,* appetizing, and presumably satisfied their hunger. A study extending over seven days, showed that the food consumed averaged 58 grammes of protein, 83 grammes of fat, 222 grammes of carbohydrate, and 1,882 calories of energy, per woman. It consisted of a variety of meat, fish, bacon, eggs, butter, milk, cheese, bread, rolls, breakfast foods, oatmeal, cornmeal, macaroni, rice, corn-starch, sugar, beans, potatoes, green vegetables, and fresh fruit. The food was adequate, well prepared, and cost eighteen cents per day. Reckoning the average age at seventy-six years, the amount of protein is somewhat below the requirement according to Maurel's standard.

A dietary study in a Baltimore home for aged women included an investigation of the food of seventy-five women whose average age was seventy-six years. The food consumed by them included 85 grammes of protein, and was calculated to yield 2,606 calories. This is almost identical with the standard which hitherto has been considered necessary—viz., 0·8 of the food of a man doing moderate work. In the adjoining home for aged men there were forty-one inmates, whose age is not stated. *They served themselves from food placed upon the table,* the bread being unlimited. The average amount consumed during the study included 82·5 grammes of protein and 2,339 calories. As this amount is slightly below the standard set for women, the natural conclusion is that 85 grammes of protein is sufficient for men in the decline of life.

In the German Home for Aged People in Baltimore in 1906 there were sixty-five men and women whose average age was seventy-eight years; the average weight of eighteen men being 145½ pounds and of twenty-nine women 137 pounds. A dietary study extending over one week showed that the protein and fuel value of the food consumed was 73·5 grammes of protein and 2,225 calories. This is practically identical with the standard for fuel-value, but was below

[1] *Zeit. f. Klin. Med.*, 1894, 437.
[2] Bulletin 223, U.S. Department of Agriculture.

the 85 grammes of protein called for by the same standard. The inmates were not restricted in the amount consumed, but could have eaten more if they wished to do so. As the women are assumed to have consumed 0·8 as much as the men, the dietary suggests that persons of extreme age can be comfortably fed and well nourished on less than 85 grammes of protein per day. The cost of the food was twelve cents per day, although 50 grammes of the protein consumed daily was supplied by animal food.

Guriev of St. Petersburg undertook some experiments to ascertain the amount of protein required by old people, and to study the metabolism of nitrogen. Five men were selected from sixty-eight to eighty-eight years of age; the three younger were hale and hearty; the two elder somewhat decrepit. Two dietaries were given in each case, the first including meat and milk, the second beef-tea, but no meat or milk. The dietaries and nitrogen balance are given in the table on p. 176.

The conclusions drawn from the observations are—(1) That the amount of protein ordinarily consumed by old men may be diminished if an abundance of fat and carbohydrate is taken to replace it. (2) The assimilation of nitrogen by old men is somewhat less than normal; during the first dietary the assimilation of nitrogen averaged 91·15 per cent.; in the second diet period, 86·17 per cent. The assimilation of nitrogen by young men on a similar diet was found by Jarwen to be 94 per cent. In the first, or meat period, the ratio of incompletely oxidized products to urea in the urine was greater than normal; therefore the metabolism is inferior to that of young men on a similar diet. In the second, or non-meat period, this ratio decreased somewhat. When the diet contained less protein but an abundance of fat, the subjects maintained their usual weight and health.

In connection with metabolism in old persons, the studies of Sonden and Tigerstedt[1] may be referred to. These studies with a respiration apparatus showed that old men and women excrete a smaller amount of carbon dioxide per square metre of surface area than middle-aged or young persons. This is considered a proof that the metabolism is less active as age advances. In youth the amount of CO_2 excreted per kilo of body-weight and per square metre of surface area is greater in males than in females. As age advances, this difference gradually diminishes, and in old age there is practically no difference between the sexes in this respect.

We have previously stated that Voit established the standard of requirements for an old man doing no work at 90 grammes of protein, and for an old woman as 80 grammes of protein, per day. In the Baltimore houses for the aged, the food consumed daily provided 85 grammes daily, except in one institution, where the diet only contained 74 grammes of protein daily. As all the inmates seemed satisfied, in good health, and well nourished, the natural

[1] *Skand. Arch. Physiol.*, 1895, p. 1.

METABOLISM IN OLD AGE.

	Protein.	Fat.	Carbohydrate.	Calories.
First diet (*a*)	90 grammes	42 grammes	372 grammes	2,286
Second diet (*b*)	55 ,,	87 ,,	385 ,,	2,615

		Days	Nitrogen : Grammes in—			Gain or loss.
			Food.	Urine.	Fæces.	
Man, 68 years	(*a*) Meat 100, milk 250, bread 600, butter 20, sugar 60, grammes; tea 1,800 c.c.	5	13·7	8·4	1·0	+4·3
	(*b*) Beef-tea 500, tea 1,800, c.c.; potatoes 600, bread 400, butter 70, sugar 60, grammes	5	8·9	6·5	·9	+2·5
Man, 74 years	(*a*) Meat 142, milk 500, bread 600, butter 22, sugar 60, grammes; tea 1,200 c.c.	10	17·4	14·6	1·2	+1·6
	(*b*) Beef-tea 500 c.c.; potatoes 300, bread 500, butter 90, sugar 60, grammes; tea 1,200 c.c.	8	10·9	7·7	·8	+2·4
Man, 75 years	(*a*) Meat 100, milk 250, bread 55, butter 20, sugar 60, grammes; tea 2,100 c.c.	5	13·0	9·0	1·2	+2·8
	(*b*) Beef-tea 500 c.c.; potatoes 600, bread 400, butter 90, sugar 60, grammes; tea 2,160 c.c.	7	8·9	6·7	1·8	+ ·4
Man, 88 years	(*a*) Meat 100, milk 500, bread 600, butter 30, sugar 60, grammes; tea 1,530 c.c.	5	15·1	10·7	1·2	+3·2
	(*b*) Bread 340, butter 120, sugar 60, potatoes 400, grammes; tea 1,530 c.c.	5	6·7	4·3	1·1	+1·3
Man, 88 years	(*a*) Meat 100, milk 250, bread 600, butter 20, sugar 60, grammes; tea 2,200 c.c.	5	13·7	10·9	1·8	+1·0
	(*b*) Beef-tea 500 c.c.; potatoes 600, bread 400, butter 90, sugar 60, grammes; tea 2,200 c.c.	8	8·9	8·1	1·4	+ ·6

inference is that these amounts are ample for the nutrition of persons in extreme old age and having comparatively little to do. The example of the Philadelphia Home for Aged Women, however, supports the contention of Maurel that less than the above amount is necessary to maintain old people, whose muscular activity is slight, in good state of nutrition. Langworthy[1] sums up the American investigation by saying that on the basis of the experimental studies in the Homes and other available data, "it seems fair to propose 0·9 as the factor representing the proportion of protein and energy required in old age by a man or woman as compared with a man at moderate muscular work during full vigour, and 0·7 or 0·8 as the factor representing the relative requirement for extreme old age." The facts elicited by these studies do not sustain the assumption that the food requirements of old women are only 0 8 that of men of the same age and activity, but suggest that the food required in extreme old age by both sexes is more or less identical.

It cannot be gainsaid, however, that in private life many thousands of old persons, even when they have a choice of food, do not consume so much as 80 or 90 grammes of protein per day. It has been shown by Chittenden and others that far less than that would be a good provision for persons in middle life who did not have to work very hard. The amount of nitrogen excreted daily during a period of starvation is about 7·0 or 7·5 grammes, equivalent to 45 grammes of protein, which is practically the same as Maurel's maintenance ration for a man of 80 years of age. Anything above that amount may be considered as being for the purpose of keeping the organism in "condition." It is a fact that people whose regular consumption of animal food is very low are not usually strong and healthy, but are weak, delicate, and predisposed to many diseases; whereas a person who consumes a fair amount of animal food is usually hale and hearty, and not predisposed to many diseases. An excessive consumption of animal food, on the other hand, tends to protein decomposition, intestinal auto-intoxication, hypertonus of the arteries, and other pathological conditions which shorten the days of the consumer. It has long since been stated that no long-lived person is a large consumer of meat; on the other hand, that a small consumption of meat tends to longevity, providing the amount consumed does not fall so low as the amount of protein disintegrated and excreted during starvation.

As an example of low protein consumption a case investigated by Buys may be quoted. The subject was a man aged sixty years, who worked in a factory ten to twelve hours a day. He had never been a large consumer of meat; indeed, from twenty years of age he had lived upon a diet consisting of bread, butter, potatoes, vegetables, and very little meat. His weight at the time of the investigation was 70 kilos. The diet during the experiment contained from 45 to 52 grammes of protein, and yielded only 1,600 calories.

[1] Bulletin 223, U.S. Department of Agriculture, p. 87.

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The nitrogen balance shows that an equilibrium would have been maintained with about 55 grammes of protein. The diets consumed were as follows:

1. *Substances eaten.*

(1) Veal, 50 grammes (one day); two eggs (one day); lean meat 30 grammes (one day); bread, 123 grammes; potatoes, 200 grammes; butter, 28 grammes; soup, 500 c.c.; coffee and milk, 400 c.c.; beer, 2,067 c.c.

(2) Veal, 140 grammes (one day); two eggs (two days); bread, 98 grammes; potatoes, 200 grammes; butter, 17 grammes; soup, 500 c.c.; coffee and milk, 400 c.c.; beer, 2,400 c.c.

(3) Veal, 40 grammes (one day); eggs, one or two (two days); beef, 26 grammes (one day); bread, 121 grammes; potatoes, 200 grammes; butter, 29 grammes; carrots, 50 grammes (one day); cabbage, 30 grammes (one day); soup, 500 grammes; milk and coffee, 400 grammes; beer, 2,867 c.c.

2. *Analysis of Diet and Excreta.*

Diet.	Days.	Food: Grammes in—			Nitrogen: Grammes in—			Gain or Loss.
		Protein.	Fat.	Carbo-hydrate.	Food.	Urine.	Fæces.	
No. 1	3	45	36	272	7·4	6·4	1·6	− 1·6
No. 2.	3	52	36	219	8·3	6·8	1·6	− 0·1
No. 3.	3	44	39	292	7·0	5·7	1·6	− 0·3

From observations made by myself amongst old people of the middle and working classes, I find that it is not uncommon for old people, whose food is unlimited, to consume as little as 50 or 60 grammes of protein daily and to continue in a fair state of health. Examples are as follows:

A man aged seventy-four and woman seventy-three years—

Total Food for Two Persons.	Protein.	Fat.	Carbohydrate.
	Grammes.	Grammes.	Grammes.
Milk, ½ pint	10·6	11·5	12·6
Oatmeal, 1½ ounces	6·6	4·5	26·7
Bacon, 3 ounces	7·6	57·6	—
Beef, 4 ounces	30·0	18·0	—
Bread, 24 ounces	60·0	—	338·2
Potato, 10½ ounces	6·0	—	66·5
Butter, 2 ounces	—	48·0	—
Sugar, 3 ounces; tea, etc.	—	—	75·0
Average per person: 1,963 calories ..	60·0	70·0	260·0

A lady, eighty years old, consumed daily—

Total Food.	Protein.	Fat.	Carbohydrate.
	Grammes.	Grammes.	Grammes.
Milk, 1 pint	21·3	23·0	25·2
Bread, 6½ ounces	15·5	1·6	88·2
Butter, 1 ounce	—	24·0	—
Meat (minced), 2½ ounces	19·0	12·0	—
Potato, 3½ ounces	2·0	—	22·0
Milk pudding, 3½ ounces	4·5	9·0	25·0
Total: 1,561 calories ..	62·0	69·6	160·2

An infirm lady, seventy-four years old, almost confined to bed, and a very small eater for twenty years, during one week, when she was considered to have consumed more than her usual quantity of food, only took an average of 20 grammes of protein, 22 grammes of fat, and 62 grammes of carbohydrates, yielding 541 calories per day. Another lady, aged eighty-one years, who was perfectly healthy except that she was confined to bed by an intracapsular fracture of the femur, ate daily an average of 3½ ounces of meat, fowl, or fish, one egg, 6 ounces of bread, ½ ounce of butter, 3½ ounces of potato, 2 ounces of milk pudding, 1 pint of milk, 1 pint of tea, 1 ounce of sugar, 5 ounces of soup, etc., containing 60 grammes of protein, 46 grammes of fat, 150 grammes of carbohydrates, and 1,290 calories.

Two ladies, sixty-five and sixty-nine years old, consumed—

Total Food.	Protein.	Fat.	Carbohydrate.
	Grammes.	Grammes.	Grammes.
Milk, 1 pint	21·2	23·0	25·2
Two eggs	13·4	11·6	—
Bread, 24 ounces	60·0	—	338·4
Mutton, 6 ounces	46·8	42·0	—
Potato, 7 ounces	4·0	—	44·0
Rice-pudding, 7 ounces	9·0	18·0	50·0
Butter, 2 ounces	—	48·0	—
Sugar, 3 ounces; tea, etc.	—	—	68·0
Average for one person: 2,064 calories	77·0	72·0	263·0

Campbell[1] says: "The physiological arguments in favour of the aged living on a spare diet seem to me to be unmistakable; in fact, mere common sense. In old age the active cells atrophy—*e.g.*, epithelial—while there is an overgrowth of comparatively inert fibrous tissue; and *pari passu* with these retrograde changes there is a general depression in the sphere of vital activity. The vital fire no

[1] *Lancet*, 1902, ii. 109.

longer blazes as in the period of lusty youth and prime, but rather smoulders and flickers. Hence, the furnace, as represented by the tissues, requires less fuel in the shape of food than in earlier years. Not only so, the atrophied digestive glands are less capable of dealing with food, and the excretory glands are less able to rid the system of the waste products to which it gives rise. . . . I find that **the healthiest, happiest, and longest lived old people are spare eaters.**

"A generous diet may be indicated in the old in certain cases—*e.g.*, I should not hesitate to increase cautiously, even to generous proportions, the diet of a starved, anæmic, old man with a low arterial pressure. There are aged persons whose metabolism has for years been habituated to an excess of stimulating diet, and for whom it is not always wise to reduce the quantity of food to slender proportions. There are, indeed, exceptional cases of old people consuming enormous quantities of food without apparent harm. This shows how difficult it is to dogmatize. There are, however, rules which, although they are not universally applicable, are yet applicable to the generality of cases. Such a principle is set forth in the aphorism: **Let the diet of the aged be spare!** I believe this to be wise counsel, dictated by common sense, sanctioned by tradition, and justified by experience."

Writing later, Campbell[1] still holds the same views, but gives an extended account of them. He gives the dietary of one of the large London workhouses. The food for men over sixty years of age consists of 20 ounces of bread, 1 ounce of margarine, 1 ounce of sugar, 4 ounces of meat, 8 ounces of potato, and 4 ounces of green vegetables a day; pudding once a week, stewed fruit twice a week; 2 pints of tea a day. This supplies 79 grammes of protein and 2,340 calories. He says this is "an ample allowance, probably in excess of actual requirements. Nevertheless most of the inmates, even the very old ones, consume the whole of their portion, and appear to enjoy it thoroughly. . . . It is noteworthy that these old people complain very little of indigestion, and, what is even more surprising, suffer little from constipation."

"An inquiry at several workhouses shows that the appetite for plain food may last to extreme old age, and their dietetic instincts are much the same as those of their younger companions. . . . Perhaps the most notable change which the dietetic instinct undergoes with advancing years is expressed by the gradual curtailment of starchy and sugary foods. . . . The factor of idiosyncrasy is an important one. Individuals differ greatly, quite irrespective of age, in their digestive and metabolic capacities. We meet with children who are quite unable to tolerate foods which old people can digest quite easily; and, again, with others who are made ill by a slight excess, while their grandparents can perhaps consume a large excess with comparative impunity. Some old people have prodigious powers of digestion and metabolism. . . . Most of

[1] Sutherland's "System of Diet and Dietetics," 1908, pp. 731-740.

these old people, however, would doubtless enjoy better health on a more abstemious diet; nevertheless in regulating their food we must make due allowance for their prodigious powers. . . . Making due allowance for the personal element, our rule obtains that while all should endeavour to conform as far as possible to the ideal dietary, allowing themselves no more than an occasional excess, it becomes with advancing years increasingly necessary for the majority of people to eat moderately of simple foods, and not to swallow starchy foods without having first insalivated them thoroughly. If we add to these rules the further ones that old people should take full advantage of dental surgery, that in the case of the toothless certain of the tougher varieties of food should be broken up mechanically before being taken, and finally that due regard should be had to the influence of idiosyncrasy and habit, we have said all that is worth saying concerning the diet of the aged."

Sir Henry Thompson[1] says: "As we increase in age—when we have spent, say, our first half-century—less energy and activity remain, and less expenditure can be made; less power to eliminate is possible at fifty than at thirty, and still less at sixty and upward. Less nutriment, therefore, must be taken in proportion as age advances, or, rather, activity diminishes, or the individual will suffer. If he continues to consume the same abundant breakfasts, substantial lunches, and heavy dinners, which at the summit of his power he could dispose of with impunity, he will in time either accumulate fat or become acquainted with gout, or rheumatism, or show signs of unhealthy deposit in some part of the body . . . which must inevitably empoison, undermine, or shorten the remaining term of his life. He must reduce his 'intake' because a smaller expenditure is an enforced condition of his existence. At seventy the man's power has further diminished, and the nutriment must correspond thereto if he desires still another term of comfortable life. And why should he not? Then at eighty, with less activity, there must be still less 'support.'" He recommends special attention to be paid to moderate exercise in the open air; and he advises a dietary which can be varied according to the idiosyncrasies of the individual, including four small meals a day—namely, breakfast about half-past eight, luncheon about one, dinner at seven, and a light supper at about eleven. The animal food for breakfast and luncheon includes egg or fish. A little meat or fowl may be taken at luncheon, unless it is preferred to reserve them for dinner, in which case fish and a farinaceous pudding may be substituted. The dinner should consist of a little *consommé*, *purée* of fish or soup, a little fowl or game, a dish of vegetables, and some light farinaceous pudding with or without fruit. The light supper, intended to promote sleep, should consist of 4 or 5 ounces of *consommé*, with an ounce of thin toasted bread. He says all bread should be toasted, and the amount for each meal should be 3 to 5 ounces before it is toasted. Butter should form a part of all

[1] "Diet in Relation to Age and Activity," 1902.

meals, and 3 or 4 ounces should be consumed daily, including that used in cooking. The beverages should consist of weak tea or coffee, with milk and aerated distilled water.

It is impossible to lay down any fixed rules for attaining longevity. It is absolutely certain, however, that heredity is a great factor in attaining it. To be born of long-lived parents, to have had grand-parents who have lived to a great age, is one of the most important items in the consideration. Another important rule is to reduce the amount of animal food consumed. This rule is not agreed to by all investigators, but in most cases it is advisable to reduce the amount of animal food to one-half of that consumed by people in middle life. Great moderation after sixty years of age is an aid to longevity. It is sometimes difficult to convince people how little food is necessary to old age when no active muscular work is being performed, especially in extreme old age, to maintain the body in health. Moderation is construed differently by different people. Some people think if they abstain from alcohol they may indulge freely in meat and other highly nutritious foods. But they cannot continue to do so with impunity, for changes will gradually develop in their bloodvessels, or they will suffer from gout, chronic disease of the liver, or kidneys. They must therefore reduce the amount of meat as well as alcohol if they wish to keep their old age free from these troubles. Sir Herman Weber[1] says: " Few people know how little food is necessary in advanced age to maintain bodily health. **Few people who live to more than eighty are large eaters of meat.** . . . I have not been able to convince myself that in healthy people a *fair amount* of meat, fish, poultry, or game, causes any bad effects. But most people enjoy better health and live longer who eat only a little meat and a larger quantity of vegetables, to which milk and its preparations may be added. . . . The food should not be bolted or moistened with much fluid during the meal; but it must be thoroughly masticated and moistened by incorporation with the saliva before it is swallowed. Most people in advanced age get thinner, and this is decidedly an advantage to those who have been corpulent, for by loss of weight they may retain their activity longer than they otherwise would do. They feel lighter, breathe freer, and may be more energetic. Some old people count this loss of weight an evil, and endeavour to remedy it by eating more food. But that is wrong; if the person is healthy, nothing need be feared from the gradual loss of weight which is evident in persons who reach an advanced age. . . . Some men retire from business at sixty to sixty-five years of age, and lose their grip of life because they take no interest in anything. This is wrong. Such men must find an interest in some object—something outside themselves; they must keep up a variety in their mental occupations, and take an interest in their surroundings, otherwise they are likely to become dejected and melancholy, and little things may burden and worry them."

[1] *Brit. Med. Jour.*, 1904.

He formulated the following rules for prolonging life:

"Pure air in and out of the house; moderation in eating and drinking; keep all the organs healthy as far as possible; take regular exercise out of doors every day in all weathers; go to bed early, rise early, sleep eight hours; keep the skin in order; have regular work or mental occupation; cultivate a placid, cheerful, hopeful state of mind; avoid anodynes, stimulants, excitement, passion, and all other injurious agencies."

Sir James Sawyer recommends: "Eight hours sleep; sleep on the right side; keep the bedroom windows open; avoid draughts; take a daily bath at the temperature of the body; eat little meat, and that well cooked; eat fat to feed the cells which destroy microbes; avoid alcohol, which destroys such cells; take daily exercise in the open air; exercise before breakfast; take frequent short holidays; limit your ambition; keep your temper."

Sir B. W. Richardson also gave the following excellent advice: "Live on light diet, with milk as the standard food, but varied according to the season; take food in moderate quantity four times a day, the last being a light meal before going to bed; clothe warmly but lightly, so that the body may at all seasons maintain its temperature; keep the body in fair exercise, the mind active and cheerful; maintain an interest in what is going on in the world, and take an active part in reasonable labours and pleasures, as though old age were not present; take plenty of sleep during sleeping hours; spend nine hours in bed, and take care that the temperature of the bedroom is maintained at about 60° F.; avoid passion, excitement, and luxury."

CHAPTER VII

SPECIAL DIETS

The mixed diet has been sufficiently discussed in the foregoing pages; but it is requisite that we should consider some of the special diets used by persons in health and disease.

Vegetarianism has the first claim on our attention, because, in a pure or modified form, it is the dietary of entire races of people, whose numbers amount to many millions. Moreover, vegetarianism has been adopted by many Europeans and Americans, who find it less costly than ordinary food, or who believe that it is conducive to health, longevity, good temper, and a mildness of disposition, or who object to eat flesh for æsthetic reasons, and consider the slaughter of animals is unjustifiable.

A *pure vegetarian* is one who seeks to nourish the body on cereals, legumes, nuts, and fruit, without the aid of animal food. Many vegetarians, however, consume milk, butter, cheese, and eggs, and are properly called *lacto-vegetarians*; they are really no more vegetarians than the man who eats meat, fish, or fowl. A lacto-vegetarian diet—that is, one consisting of milk, cheese, butter, eggs, cereals, legumes, fruit, nuts, and other vegetables—is advantageous to many people, and especially as a temporary diet in the treatment of disease. One of the chief advantages is the relative starvation which occurs in comparison with that resulting from the consumption of an equal bulk of mixed food. While getting a fairly bulky meal he no longer overeats. The amount of protein consumed is smaller, and the proportion absorbed from a vegetarian diet is considerably less than from a mixed diet. This is an advantage to many patients, and a course of lacto-vegetarian dietary such as the following is exceedingly useful in the state of high arterial tension which precedes arterio-sclerosis, some forms of renal disease—*e.g.*, Bright's disease—Graves's disease, gout, gravel, chronic rheumatism, liver trouble, constipation, intestinal fermentations, auto-intoxication, skin diseases—*e.g.*, chronic urticaria and psoriasis—neurasthenia, neuralgia, sciatica, cardiac and gastric neuroses, etc. A pure vegetarian diet is good for some of the patients; for others a lacto-vegetarian diet is better.

Lacto-Vegetarian Diet.

Breakfast.—Milk, wholemeal bread, butter, one egg.

Midday.—Baked beans and tomatoes, potatoes, cabbage, stewed fruit, bread, cheese, and salad.

Evening.—Lentil soup or oatmeal porridge, bread-and-butter, dates and walnuts, or grapes and bananas.

The dietary can be varied in an infinite variety of ways. The use of sauces of various kinds, walnut ketchup, mushroom ketchup, *fresh* mushrooms or tomatoes, with beans or macaroni, gives palatability to the meal, and provokes a secretion of gastric juice. Peas boiled with pot-herbs, mint, thyme, savoury, marjoram, endive, etc., are better flavoured than when boiled alone. The midday meal is generally that which is found most difficult to provide. The following examples of *vegetarian dinners* are sufficient for a week:

Sunday.—Savoury pie, consisting of steamed haricot beans and vegetables; or macaroni and eggs, moistened with milk and seasoned; baked potatoes; tomatoes and salad; ground rice, blancmange; fruit.

Monday.—Steamed rice and tomatoes, with grated cheese; boiled cabbage or other green vegetable; wholemeal biscuits; custard pudding.

Tuesday.—Steamed broad beans and macaroni, with parsley sauce; steamed green vegetables; potatoes cooked in their skins.

Wednesday.—Nut-roast, mushroom gravy; steamed vegetables; plain steamed pudding with jam or syrup.

Thursday.—Macaroni and cheese, with apple sauce and steamed potatoes; ginger pudding; fruit.

Friday.—Baked Irish stew, containing nut-meal or peas or beans in place of meat; milk pudding; unfermented bread; cheese.

Saturday. — Lentil-roast with apple sauce or gravy; boiled cabbage; baked or steamed potatoes; maizene pudding; nuts and fruit.

Further information on the subject can be obtained from Broadbent's "Forty Vegetarian Dinners" or Bardsley's "Recipes for Food Reformers." It may at once be granted that the composition of milk, cheese, eggs, nuts, peas, and beans, is a sufficient warrant for their use in place of meat; but the matter does not end there. Universal lacto-vegetarianism is an impossibility. "Carried out to its logical conclusion, it would have a most profound effect on life generally. Under such a scheme of diet, all animals, except those used for draught purposes and pleasure, would be gradually abolished. Were fowls used only to supply eggs and feathers, the price of eggs would rise considerably. The supply of milk would be insufficient and its price prohibitive, for cattle could not be kept for the milk and leather alone. Woollen clothing would become the luxury of the rich. The bulk of grass would be absolutely wasted. We should be dependent on cotton and linen for clothing, and compressed cellulose for boots and many other articles."[1] Before entering upon the subject of metabolism and digestion with the vegetarian diet, it may be as well to answer one or two of the assertions of vegetarians.

It is sometimes asserted that vegetarianism leads to mildness of temper or a gentle disposition. This is scarcely likely from a comparison of the animals. The buffalo, the rhinoceros, and the Chinese pirate, all vegetarians, are equally remarkable for their cunning and ferocity. The carnivora are more active and alert than herbivora. The meat-eating races of man are physically

[1] Edmund Cautley in Sutherland's "System of Diet and Dietetics," p. 197.

superior to those whose food is chiefly vegetarian. The superior physique of the European or American soldier over that of the Japanese or Hindu is obvious. The meat-eating races of mankind are more progressive than the vegetarian races. The Japanese have progressed enormously since the adoption of a larger protein ration, and especially since they took more flesh. The same remark applies to the Chinese, Siamese, and Burmese. Sufficient has been said under the head of Food in Relation to Intellectual Work to show that this influence is largely a matter of digestion. But it cannot be gainsaid that animal food is more stimulating than vegetable food, metabolism is provoked, and life is urged on more rapidly by it. The influence of vegetarian diet, therefore, is to slow down many of the vital processes, to make the person if anything less energetic, or of a quieter disposition only in proportion as all his functions become somewhat more languid. That animal food is proper for children is suggested by the fact that **milk** is the natural food of infants and young children. It may be admitted that less animal food than the amount usually consumed is really needed, and it is probable that two-thirds of the amount of protein required might be derived from vegetable sources. Hueppe says: "Man was originally a mixed feeder, but evolved into a flesh-eater, and lastly into a vegetarian; but vegetarianism only became possible after the introduction of fire and discovery of the art of cooking. Man has neither the teeth nor the gut of a vegetarian animal, or he would naturally graze in the fields in the summer, and in winter eat oats from a manger."

There is no advantage whatever in vegetarianism as a source of energy. On the contrary, there is a disadvantage owing to the vegetarian diet being less easily digested. The same amount of energy is expended in the performance of bodily functions, supply of heat, or mechanical work, whether the food is a mixed diet, a flesh diet, or a vegetarian diet. The same amount of potential energy is transformed into kinetic energy, to do the same amount of work, in the carnivorous dog, the herbivorous buffalo, and omnivorous man. The amount of energy expended by man under various circumstances has been fully discussed in a previous chapter. The energy required can be derived from a pure vegetarian diet providing the amount consumed is sufficient. But a vegetarian diet does not appear to give so much strength as a mixed diet. No vegetarian animal can lift the weight of his own body, not even the horse, ox, camel, or elephant. On the other hand, the carnivorous lion, gripping a calf his own weight, can jump a hurdle 6 feet high. The lifting power of man, *the mixed feeder*, exceeds that of any other mammal. It is recorded of Louis Cyr that he lifted 2,672 pounds; of Little that he carried 1,560 pounds for fifteen steps; of a Tyrolese that in six hours he carried a load weighing 262 pounds up an ascent 5,000 feet high. A labourer, weighing 165 pounds, working in the docks, will many times a day carry a sack weighing 220 pounds.

A vegetarian diet is not more healthful than an ordinary diet. Vegetarians contend that their diet tends to health and longevity. First of all, it must be stated that the vegetarian is quite as liable to contract disease through his food or to suffer food-poisoning as the flesh-eater. The vegetarian urges that meat causes diseases of the liver, gout, stone, gravel, chronic rheumatism, skin diseases, disturbances of the vascular system, arterio-sclerosis, kidney disease, migraine, and kindred ailments; that ptomaine-poisoning may follow the consumption of meat; that the animal consumed may be the subject of anthrax, pneumonia, tuberculosis, glanders, various worms, and other diseases communicable to man; that oysters and other shellfish disseminate typhoid fever, and so on. But unfortunately quite as many examples can be produced against vegetarian diet. An excess of bread or other starchy food from the vegetable kingdom produces indigestion, flatulence, acidity, congestion of the liver, hæmorrhoids, and promotes obesity. Sugar has an enormous value as an energy-provider, but an excess of it will produce evils similar to those following an excess of starch, and it especially causes catarrh of the stomach, attended by an abundant secretion of mucus, which envelops particles of the food, and prevents the digestive secretions from getting to and acting upon them, thereby causing indigestion and ultimately increasing the catarrh and the symptoms attending it. The ingestion of hard fruit, nuts, and fibrous vegetables, is a frequent cause of indigestion.

The communicability of disease is by no means confined to flesh foods. The advice of medical practitioners in the tropics is—"Eat no uncooked vegetable, nor any raw fruit, unless you can pare it or peel it." Enteric fever, dysentery, cholera, diarrhœa, and various other diseases have often been traced to a disregard of such advice. Even in northerly and temperate climates the consumption of raw, unripe, or over-ripe fruit, is a frequent cause of diarrhœa, choleraic diarrhœa, and has been blamed for the occasional occurrence of tropical diseases in a temperate climate. Neither are vegetables free from blame. That terrible disease hydatids is due to the *Tænia echinococcus*, a minute tapeworm which is taken into the body in the form of ova or partially developed *Tænia* on uncooked vegetables, such as watercress, celery, lettuce, etc. Actinomycosis is due to the ray fungus which enters the organism with green vegetables and cereals. Ergotism, due to the fungus *Oïdium abortifaciens*, is a disease which commonly affects the consumers of rye-bread. Pellagra has been associated with the consumption of maize, and beri-beri with rice. In fact, the superior freedom of the vegetarian diet from disease-giving properties vanishes entirely when the subject is carefully considered.

The superior health-giving properties of the vegetarian diet are also very questionable. Hueppe says: "The vegetarians of our time belong to the class of neurotic men who, failing to meet the strain of town life, ever seek for a 'heal-all' in one or other crank. Their doctrines, pushed with fanatic zeal, make no impression on

the healthy, and only tend to overthrow the balance of others who, like themselves, are the victims of unnatural modes of existence." The opinion of one who has followed the cult for some years, and known many votaries, may also be quoted. Mr. Hector Waylen[1] says he was a vegetarian for eight years, wore sandals, and went without a hat; but it gradually dawned upon him that man is somewhat different from the beasts; that if a monkey can do something, it does not follow that a man should do likewise. He says: "Vegetarians as a rule are not healthy folks. They present either a wizened and emaciated appearance, or a tendency to flabbiness. They have a poor circulation, and are liable to chills. They suffer from dyspepsia, flatulence, bad breath, and anæmia. Their liver and kidneys are commonly affected, and altogether there is a want of vitality among them. . . . They burden their stomach with masses of crude stuff, and practically deprive themselves of fat and oil; and while they daily grow thin and nervous, they think they are improving in health." He goes on to remark that when the human body is starving it begins to feed upon itself, as a camel does on its hump, and vegetarians are thus guilty of a species of cannibalism.

Concerning *the necessity* for vegetable foods, a great deal can be said. There is no doubt that green vegetables and fresh fruit are essential to the well-being of all people, but more especially to the town-dweller. It is well known that scurvy was an exceedingly common ailment in England up to the seventeenth century, and a heavy mortality was due to that cause. Gardening was then of a primitive character; cabbage, lettuce, celery, endive, potatoes, green peas, kidney beans, and many other of the vegetables highly prized in the present day were scarcely cultivated at all, or only in the gardens of the aristocratic houses, although the wild plants were used to some extent. Since then, however, horticulture has developed into a science, studied and practised by great numbers of people; vegetables now form a constant portion of our daily diet, fruit is becoming more and more a recognized part of our dietary, and in consequence the ravages of scurvy have become almost unknown. Fresh vegetables, potatoes, and fruit, contain certain salts which are necessary for the proper constitution of the blood and other fluids of the body. If they are withheld from the food for a long time, the blood becomes impoverished, and scurvy results. While admitting the necessity for vegetables and fruit in the diet, we must insist that an exclusive vegetarian diet is inconsistent with the ability of mankind to live upon all kinds of food; that vegetable foods alone entail a larger amount of work on the digestive organs, and they are not sufficiently stimulating for the active exertion which belongs to our present civilized condition. However, a vegetarian diet suits some people better than one containing meat; there are persons who constantly complain of heaviness, drowsiness, and want of energy after a dinner consisting

[1] *Brit. Med. Jour*, 1900, i., 37.

of hot meat and the usual accompaniments, who feel light and active after a vegetarian meal. It is a fact that the wealthy classes and those who have opportunity eat too largely and too frequently of meat and game, and consequently they suffer from diseases which are little known among vegetarians. But a vegetarian diet as a rule is not more healthy than a mixed diet, nor is it productive of a greater duration of life than a mixed diet; on the other hand, the cold plain facts of Insurance Companies show that the life of the vegetarians, as illustrated by entire races of people such as Bengalis, is not so valuable as that of the average European, who is a mixed feeder.

Some of the points already mentioned in regard to vegetarianism must now be viewed by the light of experiments in feeding and metabolism. The breeders of cattle, pigs, horses, and other animals have abundantly proved that, for feeding purposes, the best proportion of protein to carbohydrate is 1 : 5. European men and women who consume an ordinary mixed diet usually get from 1 : 3 to 1 : 5; but an Irish peasant gets, or used to get, ten times as much carbohydrate as protein—about 1 : 10·6—and Voit found a vegetarian in Munich whose protein and carbohydrate were in the ratio of 1 : 11. Such a low proportion of protein in the food of human beings is responsible for a high death-rate both in the young and the old, and in those who are unable to work off the excess of carbohydrate by bodily labour. The *mixed diet* supplies 37 to 39 calories of energy per kilo of body-weight, and includes 14 per cent. of protein. The *vegetarian diet* contains only 6 per cent. of protein, but yields 86 calories per kilo of body-weight. Hueppe likens the vegetarian to an over-heated steam-engine which is in danger of explosion owing to the use of a wrong kind of fuel; his digestion is forced to deal with a far greater bulk of food than is necessary, and energy is wasted in its digestion which might be used for the higher purposes of mental activity. Only in the circumstance of hard manual labour in the open air can a purely vegetarian diet be borne. There are, however, large numbers of people who live on a more or less vegetarian diet. The Irish peasantry live, or used to do, upon a diet consisting largely of potatoes, with a little milk, eggs, and pork occasionally; replacing potatoes by oatmeal, the list also represents the food of many poor people in Scotland. The poor of Germany and Russia live largely upon rye-bread, potatoes, and fat; in Italy, maize, chestnuts, and acorn-meal form an important part of the food of the peasants. The poor of India and China live largely on rice, millet, and vegetables, with more or less pulse and other legumes.

As vegetables are the chief source of carbohydrates, a deficiency of this group of foodstuffs need not be feared when the diet consists wholly or chiefly of vegetables. Carbohydrates are as a rule well absorbed, excepting cellulose, although there is a difference in the proportion absorbed. Cellulose is not absorbed to any extent in the human alimentary canal, although it is absorbed to a considerable extent by animals. The presence of cellulose in the diet

is valuable to many persons by acting as a mechanical stimulus to peristalsis; in fact, the conclusion has been arrived at that it is an essential part of the food of all animals which possess a long intestinal canal. The human intestinal canal is, proportionately, not so long as that of some herbivora, and the presence of cellulose therein has some drawbacks, but these are far outweighed by the advantages.

Deficiency of Fat in Vegetables.—A glance at the tables of composition will show that most vegetable foods are markedly deficient in fat. Such proportion of fat as is present is usually almost completely absorbed. But it should be remembered that a deficiency of fat in the body is borne as badly as a deficiency of protein. It can be made up to the amount usually consumed in a mixed diet by the use of oils, butter, vegetable butter, pea-nut butter, cocoanut butter, palm oil, palmine, and other vegetable fats. As a general rule these are used to a considerable extent by the vegetarians of Europe and America, especially those who live in the large towns and are able to obtain them easily.

Since the carbohydrates are derived almost entirely from the vegetable kingdom, and fat almost equally from the animal and vegetable kingdoms, the crux of vegetarianism revolves around the protein, and various questions have been asked in connection with this subject—*e.g.*:

1. Is vegetable protein digested, absorbed, and assimilated as well as proteins of animal origin ?

2. When absorbed into the system, has vegetable protein the same nutritive value as absorbed animal protein ?

3. Has the source of the protein any influence upon the metabolism and excretion of nitrogen ?

4. Has the source of the protein any influence upon the development of organs or the performance of their functions ?

To answer the first question a comparison of the amount absorbed from various foods is necessary. To determine the net calorific value of the food or its physiological availability, it is necessary to subtract from the gross heat value of the food the combustion value of the urine and fæces. The following are examples obtained by Rubner[1] in which these points are shown:

ABSORPTION OF THE ENTIRE FOOD DETERMINED—GROSS VALUE OF THE FOOD = 100.

	Loss per Cent.		Total Loss per Cent.	Net Availability per Cent.
	In Urine.	In Fæces.		
Mixed food (*poor in fat*)	4·70	6·00	10·70	89·3
,, ,, (*rich in fat*)	3·87	5·73	9·60	90·4
Meat	16·30	6·90	23·20	76·8
Milk	5·13	5·07	10·20	89·8
Graham bread	2·40	15·50	17·90	82·1
Rye-bread	2·20	24·30	26·50	73·5
Potatoes	2·00	5·60	7·60	92·4

[1] *Zeit. f. Biol.*, 42.

Atwater's coefficients of digestibility (p. 43) are drawn from a large number of investigations, many of which may be found in the Bulletins issued by the United States Agricultural Department; but a comparison of the proportion of protein in various foods and of the amount absorbed from each kind is even more valuable for showing the availability of the proteins in such foods. The following figures, representing the protein-content of the various foods, are derived from the first part of this book, and the proportion of protein absorbed is from the authorities whose names are given.

Food.	Protein in Food.	Protein absorbed.	Authority.
	Per Cent.	Per Cent.	
Cooked beef	27·5	97·2 to 97·5	Rubner
,, leg of mutton	25·0		,,
Hen's egg	13·5	97 to 98	Atwater
Milk	4·0	88 to 93	Rubner
Cheese	30·0	91·7	,,
Fish	18·0	97·0	Atwater
Bread: white	8·0	74·3 to 81·3	Rubner
,, wholemeal	9·7	69·5	,,
,, Graham	8·9	70·0	,,
,, rye	6·0	68·0	,,
,, bran	9·6	57·5	Meyer
,, French	8·5	78·0	Rubner
Macaroni	13·4	88·8	,,
Vermicelli	10·9	84·0	,,
Maize	14·0	84·5	,,
Maizemeal, cooked (gruel)	2·5	84·5	,,
Oatmeal	15·5	85·0	Atwater
Rice	5·0	79·0	Rubner
Tapioca	0·4	85·0	Atwater
White beans	18·25	78·0	Wait
Haricot beans	25·0	67·5	Prausnitz
Kidney beans	25·4	77·0	Wait
Lentils	22·0	60·0	Strümpell
Peas, dried (*well soaked*)	23·0	72·2 to 82·5	Rubner
Potatoes, boiled	3·5	67·8	,,
Cabbage	1·6	81·5	,,
Carrots	1·0	61·0	,,
Nuts: filberts	15·6	86·0	Atwater
,, Brazil	18·0	84·0	,,
,, pea-nuts	25·8	86·0	,,
,, walnuts	24·5	84·0	,,

The above table shows plainly that, as a source of protein, meat, fish, eggs, and cheese take the highest rank, peas, beans, and nuts follow; but bread, rice, vegetables, and fruit contain very little protein. The amount of protein absorbed or available is also highest in meat, fish, eggs, milk, and cheese; next to these it is most available in macaroni, vermicelli, oatmeal, and maizemeal. The protein of nuts follows next in order of availability, especially pea-nuts, Brazil nuts, chestnuts, and walnuts; peas, white beans, haricot beans, kidney beans, and lentils follow in the order given. The protein of fruit and vegetables is quite as easily absorbed as

that of cereals and legumes, but they are poor in this important element. It remains to be seen what is the amount of protein in the dietary of vegetarians and fruitarians, and to compare that with the composition of an ordinary mixed diet. The following table shows the average composition of the diet of fifty-three mixed feeders, and a selection of dietaries used by vegetarians and fruitarians in various studies. The figures were chiefly abstracted from the excellent study of Fruitarianism by Professor Jaffa.[1]

These dietaries show that, when compared with so-called standard dietaries, both the vegetarian and fruitarian diet is lamentably deficient in protein and fat, and in some instances was also deficient in fuel value, in one case only providing 25·4 calories per kilo of body-weight. The examples (see table, p. 193) of vegetarian dietary actually consumed are sufficient to show the mode of feeding.

1. *Man, twenty-eight years old, height* 5 *feet* 5 *inches, weight* 125 *pounds :* His daily diet consisted of: Rye-bread (*Pumpernickel*), 131 grammes (4½ ounces); Graham bread, 438 grammes (nearly 1 pound); apples, 777 grammes (1¾ pounds); dried figs, 114 grammes (4 ounces); dried dates, 247 grammes (8 ounces); oranges, 66 grammes (2 ounces); olive-oil, 21 grammes (¾ ounce). It contained protein, 54 grammes; fat, 22 grammes; carbohydrates, 573 grammes; and had a heat value of 2,775 calories.[2]

2. *Man, forty-eight years old, height* 5 *feet* 8 *inches, weight* 153 *pounds*, consumed daily: Potatoes, 1,000 grammes (2¼ pounds); hazel nuts, 166 grammes (6 ounces); pea-nuts, 12·5 grammes (½ ounce); plums, 83 grammes (3 ounces); sugar, 71 grammes (2½ ounces); raisins, 93 grammes (3½ ounces); apples, 354 grammes (¾ pound); oranges, 63 grammes (2½ ounces); olive-oil, 50 grammes (1¾ ounces). It contained protein, 63 grammes; fat, 66 grammes; carbohydrate, 593 grammes; and had a fuel value of 3,302 calories.[3]

3. The following example of a moderate vegetarian diet is given by Jaffa.[4] The subject was *a man, aged sixty-four years, height* 5 *feet* 7 *inches, weight* 136 *pounds ;* he had been a vegetarian for eleven years. The total food consumed by him during a period of twenty-four days was as follows:

	Grammes.
Cereals: granose	2,155
,, gluten flour	454
,, flaked rice	1,673
Honey	1,985
Vegetables: baked beans	1,021
Dried fruits: dates	425
,, ,, figs	28
,, ,, prunes	794
,, ,, raisins	255
	8,790
Carried forward	8,790
Fresh fruit: apples	5,585
,, ,, bananas	2,722
,, ,, grapes	3,317
,, ,, raspberries	397
Nuts: almonds	907
,, brazil nuts	1,361
,, pine-nuts	198
,, walnuts	907
Total	24,184

1 Bulletin 132, Experimental Station, U.S. Department of Agriculture.
2 Voit, *Zeit. f. Biol.*, 1889, xxv. 232.
3 Albu, *Zeit. f. Klin. Med.*, 1901, xliii. 75.
4 Bulletin 132, p 211, U.S. Department of Agriculture

THE COMPOSITION OF MIXED AND VEGETARIAN DIETARIES.

Subject.	Weight of Subject.	Nature of Dietary.	Protein.	Fat.	Carbo-hydrate.	Fuel Value.
	Pounds.		Grammes.	Grammes.	Grammes.	Calories.
Voit's standard, for moderate work	154	Mixed	118	56	500	3,055
Ranke, for intellectual work	154	,,	100	100	240	2,324
Atwater, for sedentary occupation	154	,,	100	—	—	2,700
,, for light work	154	,,	112	—	—	3,050
,, for hard work	154	,,	125	—	—	3,400
,, woman, with light work	—	,,	90	—	—	2,450
Average composition of food in 53 studies of well-to-do families	—	,,	103	138	436	3,500
Man, aged 48	153	Vegetarian	63	98	401	2,493
,, ,, 28	125	,,	54	22	573	2,775
,, ,, 19	138	,,	74	28	700	3,431
,, ,, 64	136	,,	54	77	312	2,004
,, ,, 63	124	Fruitarian	43	81	167	1,430
Woman, aged 34	93·5	Vegetarian	40	54	311	1,712
,, ,, 42	83·0	,,	34	36	227	1,399
,, ,, 42	—	,,	41	43	272	1,679
,, ,, 33	90·0	Fruitarian	33	59	150	1,300
,, ,, 33	—	,,	47	84	214	1,850
Children: Girl, aged 8	37	Vegetarian	32	82	165	1,403
,, ,, 8	37	,,	64	164	328	2,805
Boy ,, 9	—	Fruitarian	27	56	152	1,255
Girl ,, 7	35	,,	40	72	134	1,385
,, ,, 6	33	,,	24	58	134	1,190
Man, aged 19 (Rumpf)	138	Vegetarian	74	28	700	3,431
,, ,, 28 (Voit)	125	,,	54	22	573	2,775
,, ,, 48 (Albu)	153	,	63	66	593	3,302

These items provided an average weight of $2\frac{1}{4}$ pounds of food daily at a cost of $9\frac{1}{4}$ pence or $18\frac{1}{2}$ cents daily, and contained—Protein, 53·5 grammes; fat, 76·9 grammes; sugar and starch, 301·8 grammes; crude fibre, 10 grammes, daily, having a fuel value of 2,043 calories. The man was healthy and well, and lived on a dietary containing 50 to 60 grammes of protein, or about half the amount commonly accepted as being necessary for a man having a sedentary occupation.

4. The following is an example of a vegetarian diet, the fat being increased by the consumption of a small amount of fat pork, investigated by Wait,[1] the special object of the investigation being the digestibility of peas. The following shows the amount of food eaten in four days:

Ration.	Total Food for Four Days.	Contents of Food: Grammes— Protein.	Fat.	Carbohydrates.	Ash.	Energy.
	Grammes.					Calories.
Bread	1,170	112	11	679	11	3,600
Milk	2,600	81	138	132	18	2,182
Butter	130	2	116	—	4	1,048
Pork	78	4	71	—	2	670
Bananas	910	11	7	183	7	817
Sugar	130	—	—	130	—	515
Peas	1,100	219	16	684	39	4,299
Total		429	359	1,808	81	13,131
Daily average		107	90	452	20	3,283
Proportion digested: total food per cent.		78	97	94	64	88
Proportion digested: peas, per cent.		67	94	85	49	75

5. *A Roumanian peasant*, living on beans and maize, receives daily: Protein, 182 grammes; fat, 93 grammes; carbohydrate, 968 grammes.

6. The average diet of a *Japanese peasant* is estimated to contain—Protein, 102 grammes; fat, 17 grammes; carbohydrate, 578 grammes. But, according to Mori, the Japanese may be divided into three classes: (1) The rural population of the interior eat a vegetable diet almost exclusively; they only eat fish once or twice a month, and meat once or twice a year. (2) The population of the coasts eat a considerable amount of fish. (3) The residents of cities, and wealthy families all over Japan, eat both meat and fish to a considerable extent. Rice is the principal vegetable food, but in addition to this a considerable amount of barley, wheat, millet, and buckwheat are eaten Tubers, such as yams and sweet potatoes, and roots, such

[1] Bulletin 187, U.S. Department of Agriculture.

as turnips and radishes, are staple articles of food. Pumpkins, cucumbers, and other cucurbits, are much used for food. Legumes in their natural condition are not much eaten, but they form the basis of a large number of prepared foods and relishes, which are eaten by everybody. Chief among these are miso, tofu, and shoyu. *Miso* is a thick paste prepared from cooked soy-beans, which are rubbed through a sieve, and fermented with the same ferment which they use for the fermentation of rice-liquor to make wine. *Tofu is bean cheese* ; it consists essentially of the legumin of soy-beans, and is eaten fresh. It is obtained by extraction of the cooked soy-beans, rubbed into a paste, with water, and precipitated by the addition of mother-liquor obtained from the evaporation of sea-water in the manufacture of salt. The agent of the precipitation is magnesium chloride. *Shoyu* is a sauce which is extensively used; it is prepared from the soy-bean paste, obtained in the same way as that used for making miso, which is mixed with roasted and pulverized wheat, wheat-flour, salt, and water, and fermented with rice-wine ferment for one and a half to five years.

7. The Chinese peasantry live in the same way as the Japanese. All classes of people use the same or similar preparations of soy-bean, and a very large number of those who can afford it eat meat, fish, and game, and especially pork.

The answer to our first question is that the protein of vegetables is not digested, absorbed, and assimilated as well as the proteins of animal origin. A very much larger proportion of the nitrogenous compounds escapes from the influence of the digestive ferments, and this is mainly due to the difference in the solubility of the envelopes of animal and vegetable cells. With a strictly vegetarian diet, a very much larger quantity of food must be consumed to enable the consumer to digest as much protein as is usually considered necessary. The question as to whether mankind requires as much protein as that entering into so-called standard diets has been previously discussed in the section on the protein requirement. To obtain the amount of protein usually considered necessary for the organism from a purely vegetarian dietary, calls for the expenditure of a good deal more labour by the digestive organs than is required for the digestion of an ordinary mixed diet. From an economical point of view there is no doubt that the protein of legumes is cheaper than that from meat, milk, or eggs, and from this standpoint their use must be encouraged when the diet is deficient in this constituent owing to a limitation of the income.

Has vegetable protein the same physiological value when absorbed as animal protein? Vegetarians maintain that vegetable proteins are specifically different in their action from the animal proteins, and that they have a different effect on the body, and also on the character and *morale*. In the present state of our knowledge of the breaking down of all food proteins in the process of digestion, it is difficult to believe that any minute biological peculiarities pertaining

to the molecules of albumin, globulin, or other protein, are preserved. Moreover, the point is not a good one for vegetarians to raise, for it is possible that the proteins of animal origin need a less complete breaking down than vegetable proteins before they are assimilated. Proteins are all composed of amino-acids, and the proteins of animal foods have been constructed out of vegetable proteins by the consumer. All proteins do not contain the same kinds, or perhaps the same proportion of amino-acids, but in many proteins it is only the proportion that differs. There are many minute differences between the various proteins, but the differences arise from a variation in the proportion of the amino-acids. So far as the amino-acids go, it matters very little where they are obtained from, as they have practically the same value whether they are derived from the animal or vegetable kingdom.

In forming an opinion as to the exact nutritive value of foods something more is necessary than a knowledge of the nitrogen content. The actual amount of protein in many foods has never been accurately determined. It is true the amount of nitrogen has been ascertained, and from it the proportion of protein has been calculated by the factor N × 6·25 on the assumption that no other nitrogen compound is present. Both assumptions are wanting in precision. The amount of nitrogen in the numerous proteins of animal and vegetable foods differs somewhat, and the difference is from 15·0 to 19·0 per cent., 16 per cent. of nitrogen being the average, and therefore the factor varies from N × 5·26 to N × 6·66. The assumption that no other nitrogen compounds occur in a great proportion holds good in the case of cereals and legumes; but other vegetables contain *free* amino-acids, amides, ammonia, and nitrates, the unorganized nitrogen sometimes forming one-third of the total nitrogen. It would likewise be an error to consider all the nitrogen in meat as contained in proteins, because many animal tissues contain materials which yield gelatin, a substance very different from albumin or globulin, and more analogous to carbohydrates than proteins.

One of the best and surest modes of determining the *value* of the nitrogen-content of any foodstuff is by finding out the amount of protein absorbed. This has been done in regard to many foods named above, and also in metabolism experiments with vegetarians. A consideration of such figures shows that there is a great difference in the absorption of animal and vegetable foods. In fact, it would seem to be almost impossible for a man to consume sufficient vegetable food to enable him to absorb 100 grammes of protein daily. The **potato** appears to be especially unsuited to supply protein, seeing that 5 kilos of potatoes would have to be consumed to take in 100 grammes of protein, and no less than 7 kilos would be required to enable 100 grammes of protein to be assimilated. Rubner found, however, that a soldier was unable to consume more than 3 to 3½ kilos daily, although the potatoes were cooked in a variety of ways to make them appetizing, and he had perfect liberty

to consume them at any time, or to eat them all through the day. The amount consumed by this man contained only 71·5 grammes in protein, of which 23 grammes was not absorbed, but reappeared of his fæces. In his case potatoes were insufficient to maintain the nitrogen equilibrium; he excreted more nitrogen through his kidneys than he absorbed from his alimentary canal—in fact, he partly lived upon the proteins of his body. The **legumes** are better adapted to form part of a vegetarian dietary; they contain a large proportion of protein, and, although a considerable proportion is evacuated unabsorbed, both Rubner and Woroschiloff found that the nitrogen metabolism could be maintained in equilibrium when meat was replaced by peas or beans. But it would be impossible to live on peas or beans alone; 20 ounces, or 530 grammes, of pea-flour would contain 120 grammes of protein, 9 grammes of *fat*, and 360 grammes of carbohydrate, and would make twenty basins of pea-soup. But this would not be enough to maintain the nitrogen balance in equilibrium. Rubner found that 600 grammes of peas, boiled and eaten in a mush, were insufficient; but 960 grammes gave the following result: Nitrogen in food, 32·7 grammes; in urine, 21·5 grammes; in fæces, 9·1 grammes; gain to the body, 2·1 grammes. Prausnitz studied the efficiency of beans in his laboratory servant, who consumed a diet containing 500 grammes of dried white beans, 28·6 grammes of fat, 17·3 grammes of flour, salt, and vinegar. The beans were soaked in water for fifteen hours, boiled until soft, and eaten with a sauce made of flour mixed with fat, slightly browned by heat, and flavoured with vinegar. The unabsorbed protein amounted to 30·3 per cent., the nitrogen balance being as follows: Nitrogen in food, 17·9 grammes; in urine, 14·7 grammes; in fæces, 5·4 grammes; loss to the body, 2·2 grammes. From which is seen that at the lowest estimate 650 grammes of beans would be required daily to maintain the nitrogen in equilibrium. **Fruit** is not such a good source of protein as the legumes. The following was the actual amount of food consumed in twenty days (the only food of animal origin was cottage cheese, 280 grammes; the rest consisted of vegetables, fruit, and nuts): Tomatoes, 666 grammes; apples, 6,682 grammes; bananas, 118 grammes; grapes, 21,613 grammes; cantaloupe (melon), 3,714 grammes; haws, 2,471 grammes; pears, 2,804 grammes; pomegranates, 62 grammes; persimmons, 2,098 grammes; oranges, 57 grammes; strawberries, 808 grammes; water-melons, 3,955 grammes; figs, 1,309 grammes; almonds, 496 grammes; peanut-butter, 1,006 grammes; olive-oil, 207 grammes; honey, 133 grammes. The entire food gave a daily average of—Protein, 40 grammes; fat, 54 grammes; carbohydrate, 286 grammes; and had a fuel value of 1,713 calories. The deficiency in the supply and absorption of protein is one of the greatest disadvantages of the vegetarian dietary, and this deficiency is most severely felt by growing children, who need protein to build up their tissues; adults can bear a low protein diet better than children, for we have elsewhere seen that it is possible to maintain the nitrogen balance in

equilibrium when the amount of protein actually absorbed is as low as 50 to 58 grammes daily. It is claimed, however, by physiologists and those especially who have given great attention to the study of nutrition, that a low average of protein in the food is one of the chief causes of the high mortality among the poor.

The protein of vegetables is not as valuable from a nutritive point of view as that of animal origin. Protein is protein whatever its origin, and albumin or globulin is of the same nutritive value whether it be from animals or vegetables. But one cannot get away from the practical fact that meat gives a greater degree of energy than peas or beans. This may be denied by vegetarians, but it is the general experience; there is a difference in the personal feeling—*bien être*—when living on an ordinary diet from that which obtains when living on a vegetarian diet. Most vegetarians of European communities are neurotics; they do not possess the energy, activity, and endurance of an ordinary individual. Why is this ? Given an equal amount of protein from the two sources, they have an equal value so far as anybody can tell. The proteins in animal foods are albumins and globulins; those in vegetables belong chiefly to the class of globulins. There are nucleo-proteins in both animal and vegetable foods. The non-protein nitrogen of animal foods consists chiefly of the extractives, creatin, creatinin, xanthin, hypoxanthin, carnin, urea and uric acid; that of vegetables is chiefly in the form of amides and amino-acids—leucin, tyrosin, asparagin, etc. Herein lies the chief difference in the properties of animal and vegetable protein foods. The extractives of animal foods are more stimulating than those of vegetable foods. It is not contended that they give greater bodily strength. Energy is not to be confounded with muscular strength; energy is the property of the nerves, strength of the muscles. Physical work is done by the muscles, but it is initiated and controlled by the nervous system. The extractives of meat are valuable nerve stimulants. Leucin, tyrosin, and other amino-acids of a like character are not stimulants, and unless they are utilized by the cells of the intestinal mucosa in the construction of proteins, they pass on to the liver, where they are broken down into urea, uric acid, and ammonia. If they are too abundant to be broken down by the liver, they affect the organism adversely, and give rise to some of the symptoms of auto-intoxication. The last argument has been applied with equal force to the extractives and purin bodies in meat. But the display of energy by the carnivora is very much greater than that exhibited in general by the herbivora, and this is accounted for not only by the greater consumption of protein, but by the different character of the associated non-protein nitrogen compounds.

The source of protein influences the metabolism and excretion of nitrogen. The Russians use the terms "assimilation" and "metabolism" in a very definite sense, which we might advantageously imitate. They use the term *assimilated nitrogen* for that

which is digested and absorbed. *Quantitative metabolism* is the term used by them to mean *the ratio of the nitrogen in the urine to the assimilated nitrogen*. *Qualitative metabolism* means the ratio of partially oxidized nitrogen in urine—*i.e.*, nitrogen of extractives —to nitrogen of urea. The normal value of this ratio in man is assumed to be 1 : 14. Metabolism is qualitatively increased if this ratio is less than normal, and decreased if it is greater than normal. Having these points in view, Baftalovski of St. Petersburg made a number of observations on men with (1) animal diet, (2) mixed diet, and (3) varied vegetable diet. He summed up his results as follows: *The total nitrogen of urine*, nitrogen of urea, nitrogen of extractives, and uric acids, was greatest on the animal diet and least on the vegetable diet. A varied vegetable diet caused an excretion of only half as much nitrogen in the urine as when animal food was consumed, and only a quarter as much as when ordinary mixed food was eaten. On an animal diet the ratio of nitrogen of urea to the nitrogen of extractives was less than on a varied vegetable diet, and greater than on a mixed diet. On a mixed diet the ratio of nitrogen of urea to nitrogen of extractives was less than on either animal or vegetable foods. With a vegetable diet less urea and extractives was excreted than on a mixed or animal food, because less was absorbed. The total solids in the urine were nearly the same on a mixed diet and animal diet, but were the greatest on a vegetarian diet. The assimilation and metabolism were most complete on an animal diet, and least complete on vegetable diet. The organism was able to maintain nitrogen equilibrium on a varied vegetable diet, unless too much work was performed. With an unvaried vegetable diet the metabolism (ratio of N in urine to N of digested food) increased 300 per cent. over normal, and a protein famine resulted. When animal and unvaried vegetable food was consumed, the weight of the body decreased, but it increased on a mixed and a varied vegetable diet. An example may be taken from his observations. The subject was a physician, aged forty-two years, weight 57 kilos.

Kind of Food.	Nitrogen: Grammes in—				Gain or Loss.
	Days.	Food.	Urine.	Fæces.	
Animal	3	25·4	24·0	1·1	+ 0·3
Mixed	3	22·9	19·2	2·1	+ 1·6
Vegetable	3	13·0	11·8	2·3	− 1·1

Some observations of other investigators may also be quoted. A certain amount of nitrogen is excreted by the kidneys even when no food is consumed; and Voit found that when the food consisted of fat and carbohydrates—that is, a sufficiency of energy-producing

material, but no nitrogen—the subject excreted 9·5 grammes of nitrogen in the urine. When the same subject fed on a vegetarian diet containing 8·3 grammes of nitrogen, the nitrogen equilibrium was not maintained—in fact, it was not all assimilated, and there was a deficiency of 4·9 grammes. Taniguti found that the balance was exactly maintained in a Japanese subject when the food, consisting of miso, rice, and other vegetables, contained 10·5 grammes of nitrogen per diem. The more food consumed the greater was the amount of nitrogen excreted, and the excretion was greater when animal food was consumed than when the diet was wholly vegetarian. This is confirmed by the observations of Baftolovski and Avsitidiski. Take two examples from the work of the latter:

1. Man A, weighing 71 kilos, was fed first with (*a*) *mixed diet* for ten days, consisting of 304 grammes of meat, 800 grammes of bread, 50 grammes of butter, 700 c.c. of bouillon, and 2,270 c.c. of water. (*b*) He was then fed for ten days with the following *vegetarian diet:* 1,000 grammes of bread, 693 grammes of peasoup, 153 grammes of buckwheat, 267 grammes of wheatmeal, 140 grammes of macaroni, 30 grammes of butter, 50 grammes of sugar, 300 grammes of potatoes (two days), 380 grammes of peas (one day), 124 grammes of rice (one day), 200 grammes of cabbage (one day), 2,270 c.c. of water.

2. Man B, weighing 69 kilos, had similar food. The results were as follows:

Subject and Diet.	Nitrogen: Grammes in—				Gain or Loss.
	Days.	Food.	Urine.	Fæces.	
Man A, Mixed	10	30·0	26·0	1·9	+2·1
„ Vegetarian	10	27·5	16·7	4·5	+6·3
Man B, Mixed	10	28·6	23·2	2·8	+2·6
„ Vegetarian	10	26·8	17·5	3·9	+5·4

The results of all observations show that the amount of nitrogen in the urine is always greater after animal food than after vegetable food; they clearly indicate that *metabolism is stimulated by animal foods*, that vegetable foods, even when the same amount of nitrogen is consumed, are not so readily assimilated—*they do not stimulate metabolism* to the same extent, and they tend to the accumulation of flesh or fat in the organism.

Has the character of the protein any influence upon the development of organs and the performance of their functions? The importance of a sufficiency of protein in the food cannot be dwelt upon too much. It is, moreover, in the period of growth and development of the body that an abundance of proteins is required. A low protein diet is, in the minds of most physiologists, un-

suitable for growing children and young adults. Nevertheless there are many thousands of growing children who get only a low protein diet, and whose protein is chiefly vegetable in its origin But the question now is, Has the *kind* of protein any influence at this period? The consumption of meat in England to-day is said to be seventeen times greater per person per annum than it was in 1850. In the intervening period there has been a marked decline in the birth-rate. It is also a fact that the decline in the birth-rate is most marked in those classes of people who have an unrestricted use of the more expensive proteins of flesh-foods, meat, game, fowl, and fish. On the other hand, the most fertile people are the poorest, or those whose consumption of animal proteins is restricted by its cost, and whose proteins are chiefly those of vegetable origin. It is believed by some authorities that the increasing consumption of meat and other animal foods affects the development of the organs of generation, acts prejudicially upon reproduction and lactation, and is thereby an important factor in the causation of the declining birth-rate and diminishing power of lactation. This opinion seems to be confirmed by experiments on animals. W. P. Watson[1] made observations on rats. The comparison was between rats fed from birth on meat alone, and others fed on bread and milk. The "meat-fed rats" were less fertile than the others, and their mammary glands not so well developed. There was no marked difference in the structure of the mammæ; but whereas the mammæ of "bread-and-milk rats" averaged 9·6 per cent. of the weight of the body, those of "meat-fed rats" averaged only 8·2 per cent. Malcolm Campbell[2] studied the effects of meat and vegetarian diet upon the generative organs of rats, and found that there was a marked difference in the development of the generative organs and of fertility. He arrived at the following conclusions: The exclusive use of (1) a diet of flesh, (2) rice or porridge, induces, in the majority of cases, a modification in the structure of the uterine mucous membrane; this modification appears to consist in a diminution of the number of large cells of the connective-tissue type, which appear to be important constituents of a physiologically active uterine mucosa. This structural change was most profound in animals fed from weaning entirely with meat; in most of these animals the development of the uterus was also much interfered with. This structural change is also associated with sterility, and the investigation shows that the sterility is probably due to the structural and developmental abnormalities of the uterus, induced by the abnormal diet.

These conclusions cannot be accepted without further evidence. The fecundity of the poor and comparative sterility of the rich in highly civilized communities is matter of common knowledge. But to assert that one condition is due to a vegetarian or low protein diet, and the other to animal proteins or a high protein diet, is at present beyond our power. There is, in fact, very good evidence

[1] *Brit. Med. Jour.*, 1907, i. 193. [2] *Ibid.*, 1,229.

that a flesh diet does not diminish fecundity when the consumers live a normal life. The Equimaux women are not sterile. The Indians of the Pampas, who live largely on a flesh diet, are very fertile. The Boer women eat meat at every meal, vegetables and potatoes being seldom seen on their tables; nevertheless they are most prolific, and feed their children by the breast. P. Watson considers these facts do not upset his theory. The subject of diet cannot be considered without reference to the habits and environment. The open-air life and activity of the Boer women are in marked contrast to the conditions generally obtaining in this country, and it may well be that the large amount of meat eaten by the Boers cannot be regarded for them as an excessive meat diet. In his experiments on rats in confinement the quantity of meat consumed was certainly excessive, and its use undoubtedly diminished fecundity. It was this conclusion which led him, in connection with the increased consumption of animal food by human beings, to suggest that the latter might be one of the causes of the diminished birth-rate or fertility of women and their power of lactation at the present day. The well-known fertility of the Boers and Pampas Indians is in no way incompatible with this theory.

The Fruitarian Diet.—Numerous experiments in metabolism have shown that it is possible for some persons to maintain their nitrogen balance in equilibrium with a diet consisting entirely of fruit and nuts. The investigations by Jaffa of fruitarians in California have a high value. Fruitarianism is a system of feeding which has spread very considerably during the past few years. However pleasant and agreeable it may be to the consumer, it is at the best a low protein diet, and seldom contains more than 50 or 60 grammes of protein, or from 8 to 10 grammes of nitrogen daily. It is unnecessary to repeat the arguments for or against the low protein diet, which have been considered in another chapter. In spite of the fact that Chittenden and other physiologists have found 8 to 10 grammes of nitrogen in the daily food sufficient for the physiological needs of the body, and that people have maintained their health and vigour for years on fruitarian and other low-protein diets, they seldom look robust. The fruitarian diet, like the more common vegetarian diet, must be looked upon as being of doubtful value, and as quite unlikely to become a regular method of feeding among people who have the desire and taste for flesh-foods ingrained in them. There are, however, certain states of ill-health in which the use of a fruitarian diet is undoubtedly of great value as a temporary measure, and such cases will be mentioned farther on. As regards the nutritive value of the fruitarian diet, a single example taken from Jaffa's investigations, and a summary of other diets, will be sufficient. Those who desire further examples can refer to the original work.[1] The subject of this investigation was a healthy and vigorous University student, aged twenty-two years, prominent in athletics. For the first week he ate his ordinary

[1] Bulletin 132, Experimental Station, U.S. Department of Agriculture.

mixed food, the next nine days he consumed a diet in which fruit replaced a large proportion of the meat, eggs, fish, milk, and cereals; finally he consumed for eight days a diet consisting entirely of fruit and nuts. The amount and composition of the food and the amount digested is shown in the table on pp. 204 and 205.

An examination of the urine and fæces of other consumers showed that in many instances, although the diet was of a low protein character, the amount of protein digested and absorbed from the food was enough to maintain the nitrogen balance in equilibrium under the circumstances of the experiment. When the amount consumed daily consisted of 5½ pounds of grapes, 6 ounces of walnuts, and a little granose, there was an actual gain of 1·29 grammes of nitrogen, equal to 8 grammes of protein. In another instance the average daily consumption consisted of 4¼ pounds of apples, 8 ounces of dried figs, and 4¾ ounces of walnuts, which also resulted in a gain of 1·28 grammes of nitrogen, or 8 grammes of protein. With a diet averaging 3½ pounds of apples, 9⅓ ounces of dates, 6 ounces of peanuts, a little granose, milk, olive-oil, and tomato, the gain of nitrogen was 2·26 grammes, equal to 14·13 grammes of protein. With 5½ pounds of pears, 7 ounces of walnuts, a little granose and milk, there was a gain of 4·25 grammes of nitrogen, equivalent to 26·5 grammes of protein; and with a diet averaging 16 ounces of walnuts, 18½ ounces of dried prunes, and 18 ounces of oranges, there was a gain of 3·42 grammes of nitrogen, or 21·38 grammes of protein.

The experiments in feeding with bananas did not give such good results. In No. 1, bananas, dates, and walnuts resulted in a *loss* of 1·82 grammes of nitrogen, or 11·38 grammes of protein; bananas, oranges, and walnuts gave a deficiency of 1·89 grammes of nitrogen, or 11·8 grammes of protein. The consumption of 5 pounds of bananas a day resulted in a loss of 1·34 grammes of nitrogen, or 8·38 grammes of protein; 4 pounds of bananas and 4½ ounces of almonds daily, gave a deficiency of 0·86 gramme of nitrogen, or 5·38 grammes of protein; 2½ pounds of bananas, 21 ounces of oranges, and 5 ounces of peccan nuts, gave a deficiency of 1·69 grammes of nitrogen, or 10·56 grammes of protein. A diet of 22 ounces of dates, 2¾ ounces of almonds, and 12 ounces of olives, gave a deficiency of 2·06 grammes of nitrogen, or 12·88 grammes of protein. A diet of pears and cocoanut gave a loss of 1·57 grammes of nitrogen and 8·8 grammes of protein. The deficiency is not great in any of these cases; but the continued daily loss of 1 or 2 grammes of nitrogen by the body is deleterious, and must ultimately result in ill-health. It is possible, as we have seen, to prevent such a loss by means of a carefully regulated diet; but it is difficult for the non-scientific subject to adjust his diet so carefully to the needs of the body. In this respect, therefore, we are bound to state that very few fruitarian diets contain enough protein to maintain the nitrogen balance in equilibrium; and still fewer contain the amount of protein required by the standards set up by numerous authorities. The

AN EXAMPLE AND SUMMARY OF FRUITARIAN DIETS.

Kind of Food.	Weight of Food.	Nitrogen.	Protein.	Fat.	Carbohydrates. Sugar, Starch, etc.	Carbohydrates. Fibre.	Ash.	Heat of Combustion.
	Grammes.	Grammes.	Grammes.	Grammes.	Grammes.	Grammes.	Grammes.	Calories.
1. *First four days :*								
Bananas	3,005	4·86	30·35	4·51	372·90	9·9	15·24	1,768
Dates	964	4·16	26·03	2·89	495·50	20·2	12·53	2,250
Walnuts	1,290	20·08	125·50	321·41	24·20	9·5	9·80	3,722
Total	5,517	29·10	181·88	328·81	1150·60	39·7	37·57	8,728
Amount digested ..	—	20·24	126·52	249·34	1088·00	31·3	14·63	7,284
Second four days :								
Bananas	2,438	3·93	24·62	3·66	392·50	8·0	12·43	1,434
Oranges	4,054	6·09	38·11	5·27	326·70	17·8	19·05	1,663
Walnuts	1,304	20·30	126·89	324·90	24·50	9·6	9·91	3,784
Sugar	190	—	—	—	190·00	—	—	751
Total	7,986	30·32	189·62	333·92	843·70	35·5	41·39	7,632
Amount digested ..	—	21·61	135·21	247·99	787·90	26·2	14·75	6,153
Total food in eight days ..	13,503	59·42	378·50	662·73	1994·30	75·2	78·96	16,360
Total digested in eight days	—	41·85	261·73	497·33	1875·90	57·5	29·38	14,437
Average digested per day ..	—	5·23	32·72	62·17	234·50	7·2	3·67	1,803

Kind of Food.	Weight.	Nitrogen.	Protein.	Fat.	Carbohydrates (Sugar, Starch, etc.).	Heat of Combustion.
		Grammes.	Grammes.	Grammes.	Grammes.	Calories.
2. Bananas, 5 pounds	Consumed	3·51	21·95	3·26	269·40	1,279
	Digested	2·67	16·69	·62	261·64	1,181
3. Bananas and almonds	Consumed	6·13	38·60	68·00	241·39	1,868
	Digested	4·32	27·01	57·54	229·59	1,632
4. Bananas, oranges, and peccans	Consumed	6·25	39·12	104·00	192·35	2,010
	Digested	4·42	27·67	93·43	181·57	1,785
5. Oranges, dried prunes, and walnuts	Consumed	6·90	46·23	89·03	258·90	2,160
	Digested	6·17	38·56	78·66	252·45	1,975
6. Dates, olives, and almonds ..	Consumed	5·98	37·39	109·02	442·10	2,663
	Digested	3·94	24·65	91·75	315·20	2,252
7. Apples, peanuts, dates, granose, milk, olive-oil	Consumed	12·37	77·33	104·53	383·14	3,038
	Digested	9·68	60·43	86·26	372·23	2,709
8. Apples, walnuts, dried figs, granose, and milk	Consumed	10·27	64·20	110·40	382·05	3,012
	Digested	7·22	45·44	97·40	374·00	2,703
9. Pears and walnuts, granose and milk	Consumed	11·46	71·65	143·12	345·00	3,135
	Digested	9·64	60·26	121·70	342·05	2,870
10. Persimmons and peanuts, tomatoes, granose, olive-oil	Consumed	15·00	93·74	120·80	256·00	2,832
	Digested	13·02	81·36	107·13	243·51	2,503
11. Grapes and walnuts, granose	Consumed	8·62	52·87	116·26	213·65	2,287
	Digested	6·88	42·97	104·06	207·60	2,070
12. Grapes and Brazil nuts, tomatoes, granose, and olive-oil	Consumed	10·64	66·61	83·56	382·52	2,793
	Digested	9·11	56·91	70·43	372·80	2,558

amount of fat in the food is also almost always below the standard required, and only reaches the standard when the food contains a large proportion of nuts, olives, or olive-oil. The nutriment in fruit consists chiefly of carbohydrates, the digestibility of which compares very favourably with the carbohydrates in a mixed diet. Respecting the heat-value of the food, the above table shows that the amount of energy yielded by the food is greater in proportion to the amount of fat; it is low with bananas, but better when bananas and nuts are consumed together; it is also low with apples, pears, or grapes as a diet, but is considerably improved by the consumption of half a pound of brazil nuts, peccans, or walnuts. A diet of apples, figs, and walnuts, or of pears, figs, and walnuts, is capable of supplying enough protein, fat, and carbohydrate for the use of the body, and with sufficient energy for a man doing moderate work.

Fruit in Sickness or Ill-Health.—A diet of fruit or fruit and nuts is useful as a temporary mode of feeding in all cases where it is considered desirable to reduce the consumption of protein, and especially when it is considered necessary to exclude the purin bodies as much as possible. When an ordinary fruit and nut diet is taken, the nuts should be ground in a mill, the food should be eaten slowly, carefully masticated, and consumed in moderation; and the meals should not exceed three in a day, and many people are better with two meals than with three. But the "fruit cure" is especially valuable in the case of gross feeders, who clog their system with a superfluity of food and drink; for those who awake in the morning with a disagreeable taste in the mouth, a headache, and other disagreeable symptoms; in many cases of albuminuria, intestinal fermentation, chronic diarrhœa; and in obesity, gout, migraine, eczema, urticaria, and other diseases which are the heritage of a pernicious system of feeding in the wealthy, and even more particularly in families which, having lived quiet and simple lives in the country, modify their manner of living when they better themselves socially. The "fruit cure" is a form of treatment for these cases, available for all classes. It is poor in proteins. It increases the alkalinity of the blood, decreases the acidity of the urine, is diuretic and laxative, lessens intestinal fermentation, and stimulates the action of the liver. In acute nephritis, fruit, such as raisins, oranges, and pears, will supplement the carbohydrates of the milk. Under mixed treatment of albuminuria, milk and fruits lessen the albuminuria, diuresis is encouraged, and œdema disappears. If it is desired to increase the weight of the patient, some raisins may be taken along with a diet rich in fat and albumin. If it is desired to decrease the weight of the patient, a large quantity of raisins or raisin juice may be taken with a corresponding reduction of proteins and fats, other fruits and vegetables being taken at the same time. Moreover, it is useful, if the patient, is on ordinary diet, to recommend a "fast-day" once a week, when the only food should consist of apples, grapes, bananas, or some other fruit.

"Apple-fasts" have been recommended to many persons, especially those who are undergoing a reduction of their weight, and in the treatment of gout, gravel, chronic rheumatism, chronic liver troubles, Bright's disease, and in the condition of high arterial tension which precedes arterio-sclerosis and some forms of renal disease, in intestinal fermentations, chronic constipation, etc. "Fasts" of this nature do not agree equally well with all patients, and there are some persons who cannot bear abstention from their ordinary food for so long as twenty-four hours, even though they may consume an equal bulk of fruit.

The use of fruit in the treatment of acute febrile affections is very ancient. Grapes, strawberries, oranges, bananas, and *cooked* apples may in many cases be eaten freely. The fruit juices are exceedingly valuable as an aid to treatment; they increase the secretion of urine and its alkalinity, stimulate the kidneys, and, indirectly, the skin; at the same time they are cooling and refreshing. The juice of grapes, oranges, pineapples, currants, gooseberries, raspberries, strawberries, may be freely used. *Lemon-juice* is one of the commonest articles in a sick-room; in the form of lemon-water, lemonade, or combined with eggs, it is most useful. The white of an egg in $\frac{1}{4}$ pint of lemon-water, sweetened with sugar, is very nutritious. The whole of a raw egg may be beaten up, mixed with $\frac{1}{3}$ pint of lemon-water, and sweetened with sugar. *Orangeade*, made by adding the juice of oranges to an infusion of fresh orange-peel in water, sweetened with sugar, is also agreeable in febrile conditions. Oranges are as useful in illness as they are acceptable in health; in febrile conditions their juicy pulp is antifebrile, and has been credited with specific curative properties in influenza. *Tamarind whey*, made by mixing 1 ounce of tamarind pulp with $1\frac{1}{2}$ pints of hot milk, is a refrigerant beverage. But the use of milk should not be forgotten; from $2\frac{1}{2}$ to 3 pints of milk daily should be taken in acute affections, in combination with a diet of fruit or fruit-juice.

The Grape Cure.—This is the chief example of the one-fruit cure. It has long been practised in the Tyrol, at Montreux, Meran, Gries, Botzen, Wiesbaden, and other places; and it can be carried out wherever the grapes are available. The "cure" occupies six or seven weeks, and consists of the consumption of from 3 to 12 pounds or more of grapes per day, the quantity being gradually increased. The rest of the food, as well as the amount of fruit, should be in accordance with medical instructions. The mastication of a large number of grapes is said to injure the enamel of the teeth, and may cause soreness of the mouth; this is best prevented by eating a little bread after the fruit, or washing the mouth with a solution of bicarbonate of soda, and by avoiding the mastication of the fruit, the grapes being swallowed after just cracking them with the tongue. The treatment is begun by the consumption of 2 pounds a day—*i.e.*, $\frac{1}{2}$ pound before breakfast, $\frac{1}{2}$ pound in the middle of the morning, $\frac{1}{2}$ pound after the midday meal, and $\frac{1}{2}$ pound about 5 p.m. The

time and amount of the increase depends upon the disease and condition of the patient. In pulmonary cases it is rarely advisable to prescribe more than 2 pounds a day; in gastric and intestinal catarrh, 3 pounds daily is the usual quantity; 4 pounds being the amount in gouty conditions, calculus, vesical affections, hæmorrhoids, chronic constipation, etc., and from 5 to 6 pounds in abdominal plethora, with hepatic congestion and chronic constipation. As a cure for phthisis, the value depends entirely on the liberal feeding and climatic conditions; and care must be taken that diarrhœa is not induced by the use of the fruit. People who are convalescent from many diseases, those who are overworked or suffering from various debilitating causes, will find the "cure" useful to them in proportion to the benefit derived from change of climate and occupation. The corpulent and obese derive great benefit from the "cure" when it is associated with a spare diet, restricted in the amount of fat and carbohydrate. The laxative effect of the "cure" begins in three or four days, and is of great service in relieving the abdominal plethora resulting from passive congestions due to cardiac debility, chronic bronchitis and emphysema, chronic constipation, liver disease, and other causes of portal congestion. In some cases the effect of the cure is enhanced by the low protein value of the diet—*e.g.*, gout and gouty concretions; in others, such as chronic constipation, gastric and intestinal catarrh, by the mechanical effect of the skins and seeds; and, in another group of cases, by the diuretic effect of the sugar and potassium salts; and in obesity by allaying the craving for food when on a diminished diet.

The Lemon Cure is an ancient practice in the treatment of gout and obesity, and is very useful when combined with hot-air or steam-baths. The juice of two or three fresh lemons is taken in sweetened water three times a day; meanwhile, milk and fatty foods are avoided. Preserved lemon-juice is not so effective as that from fresh fruit; neither is citric acid. It is doubtful whether there is any scientific basis for the consumption of lemon-juice as an antifat and antigout remedy. The use of citric acid in the quack remedies for obesity has long been known; indeed many of these remedies contain little else. The effect upon the food, if any, lies in the direction of the digestion of fat and carbohydrates; the citric acid appears to have an inhibitory power over steapsin and amylopsin.

Meat Diets—(*a*) *Meat Exclusively*.—A diet consisting entirely of meat has been used in the treatment of tuberculosis, on the following grounds: It may be assumed that the association of gout with free living is mainly due to the consumption of an excessive amount of meat, game, and other flesh foods; that a gouty condition can be artificially induced by a diet consisting largely of meat; and it is believed that there is an antagonism between the gouty condition and tuberculosis. The object of the exclusive meat diet therefore is to induce that condition which is believed to be antagonistic to

the growth of *Bacillus tuberculosis* or to its toxins. When this method of feeding is adopted, the meat must be freed from bone, gristle, and connective tissue, and lightly cooked. It must be taken in sufficient quantity to supply the heat expended by the body: 2,000 to 2,700 calories or more, according to the condition or occupation of the patient.

The patient must consume from 2 to 2½ pounds of the edible portion of average beef or mutton, to supply the body with enough fuel to meet the demands of the organism. One pound equals 453 grammes. Rubner experimented with the whole meat diet upon a healthy medical student. The food consisted of 738 to 884 grammes of beef, freed from fat, gristle, connective tissue, and bone, and cooked with a little butter, onion, salt, and pepper. The beverage consisted of water or aerated water. Specimens of the food, after cooking it, were analyzed to determine the amount of protein and fat. For this purpose the dried fat-free flesh was supposed to contain 14·11 per cent. of nitrogen. It was well digested, the fæces containing only 1·2 grammes of nitrogen, or about 7 grammes of protein. The nitrogen balance was maintained, and a slight gain to the body resulted. Solntzer also experimented with beef and mutton; Atwater experimented with both beef and fish. The results of some of these experiments, as regards the nitrogen balance, are as follows:

METABOLISM WITH MEAT DIET.

Food, per Diem.	Days.	Nitrogen: Grammes in—			Gain or Loss.	Authority.
		Food.	Urine.	Fæces.		
Beef, 884 grammes ..	3	48·8	47·2	1·2	+ 0·4	Rubner..
,, 738 ,, ..	3	39·8	37·6	1·1	+ 1·1	
,, 715 ,, ..	1	31·9	25·6	4·6	+ 1·7	Solntzer.
Mutton, 1,671 grammes	1	90·9	58·5	5·0	+ 27·4	
,, 1,336 ,,	1	56·4	50·5	3·9	+ 2·0	
Canned beef, 895 grammes	1	43·9	27·8	7·5	+ 8·6	
Canned mutton, 1,643 grammes	1	75·2	65·3	8·6	+ 1·3	
Beef, 1,200; butter, 30; wine, 367; beer, 1,250, grammes	3	38·5	37·2	1·0	+ 0·3	Atwater.
Fish, 1,549; butter, 50; wine, 700; beer, 1,250, grammes	3	45·6	44·1	0·9	+ 0·6	

An entire meat diet is also used in the treatment of obesity, chronic articular gout, diabetes, dyspepsia, and psoriasis. As a treatment for chronic dyspepsia, especially when the condition is that of atony, dilatation of the stomach, or hyperchlorhydria, its value is undoubted. It is, however, essential that sufficient nutriment be consumed to meet the demands of the body. When a

person is lying in bed, absolutely at rest, the heat expended by the body amounts to at least 1,600 calories; and the food consumed should not supply less than this amount of heat. The quantity of meat should not be less than 6 ounces of cooked minced meat three times a day; the intervals being four and a half to five hours. With this unusual quantity of nitrogen, plenty of liquids, preferably hot water, must be taken. The simplicity of the diet and its freedom from carbohydrate are the chief features of the treatment. Its chief value in obesity, diabetes, gout, and other affections, is likewise due to the absence of carbohydrate. *The Salisbury meat-cure* lasts from four to twelve weeks. The food consists of 2 to 4 pounds of beef freed from fat, gristle, connective tissue, and bone; it is chopped very fine, made into patties about 3 inches in diameter and 1 inch thick, and fried in a pan without fat or water; they are heated rapidly on one side and then on the other to coagulate the albumin, and afterwards cooked more slowly, and slightly underdone. During the first period (two or three weeks) no other food was allowed by Salisbury excepting 6 pints of hot water, to be taken thus: 1 pint in the morning while dressing, 1 pint with the breakfast, 1 pint before the midday meal, 1 pint at 4 p.m., 1 pint at 7.30 p.m., and 1 pint at 10 p.m. It is allowed to flavour the water with lemon-juice. It is also now usual to allow the meat to be eaten with salt, pepper, mustard, horseradish, celery-salt, butter, and various commercial sauces and relishes. The diet was modified by Towers-Smith, who had great success in the treatment of obesity and other diseases by means of it.

2. *Zomotherapy*, or treatment by raw meat and raw-meat juice. Some years ago Richet and Héricourt called attention to the remarkable results obtained by treating tuberculous patients with *raw meat*, and also to the effects a raw-meat diet had in enabling animals which had been inoculated with tubercle to resist that infection. Since that time raw meat has become recognized as a valuable aid in the treatment of tuberculosis, anæmia, chlorosis, gastric and duodenal ulcer, and other conditions. The amount of *raw meat* recommended is 1 pound daily, no cooked meat being allowed; but there are very few people who can take the prescribed quantity; in fact, it is seldom that more than ¼ or ½ pound is consumed, even when it is taken in aspic and seasoned with ketchup. There are various objections to the consumption of raw meat, such as the risks of tænia and other parasites, and it involves a considerable amount of trouble in reducing it to a pulp. Raw meat is an ancient remedy; but in recent times it was first recommended by Fuster of Montpellier for phthisis, empyema, and other suppurative diseases. It is now prescribed in that state of debility known as "prephthisis," in early phthisis, latent phthisis, and tuberculosis, in anæmia, general debility, neurasthenia, convalescence from acute illness, and after severe hæmorrhage. It produces an increase of vigour and muscular power, the proportion of hæmoglobin is increased, the blood-pressure is raised, digestion improved, weight

increased, and the physical signs of phthisis or tuberculosis are abated. The treatment is continued for at least one month, and in many cases for a period varying with the extent of the disease and the improvement obtained. The treatment is contra-indicated in cases of hæmoptysis, or when the nervous system is easily excited, in the arthritic condition, various forms of intoxication, and disease of the liver or kidneys.

Raw-Meat Juice.—Since the publication, in 1889, of Richet and Héricourt's observations on the effect of raw meat on the progress of tuberculosis in dogs, they have continued their experiments for the purpose of discovering a means of arresting tuberculosis. In a recent paper on the subject,[1] Héricourt says: "It is probably no exaggeration to say that the raw-meat treatment of pulmonary phthisis yields results not approached by any other means at present available." With this experience Professor Richet and he undertook researches to find out which constituent in the muscular tissue it is which exercises this antagonism to the progress of tuberculosis. They found that the solid constituents of the flesh had no therapeutical action; indeed, "tuberculized animals fed on flesh from which the muscle plasma had been expressed died in approximately the same lapse of time as the control animals who were fed with ordinary food. But the administration of the expressed meat-juice to other tuberculized animals prevented infection taking place; these animals did not fall ill, but they remained in particularly robust health, showing a substantial increase in weight after an interval of several weeks. When the muscle-juice was given to animals actually under the empire of tuberculous infection, the emaciation ceased, and they were restored to health, while the control animals died."[2] The deduction is that the agent of raw meat which produces this effect resides in the muscle plasma—*i.e.*, the meat-juice; and the method of treatment, based on the administration of meat-juice as a remedial agent, is called by them "zomotherapy," from Ζωμός, meat-juice. Héricourt points out[3] that heat destroys the organic principles to which the efficacy of raw meat is due; and that the same effect is not obtained from forced feeding with cooked meat, nor with any liquid preparation such as "liquid meat," "meat-juice," or "meat extracts," which have been manufactured by the aid of heat. The latter substances are valuable foods, but "they possess none of the therapeutical properties which are inherent to raw meat." There is some difficulty in obtaining the meat-juice; but various presses are sold by which it can be got. An ordinary domestic press will yield about 25 per cent. of juice; and the more powerful presses from 40 to 50 per cent. The juice should be collected in a vessel surrounded by ice and consumed as soon as possible. The meat should be perfectly *fresh*, obtained within two or three hours after being slaughtered in the summer, and four hours in the winter. Héricourt considers this is a most important

[1] *Lancet*, 1911, i. 22. [2] *Ibid.* [3] *Loc. cit.*

point; because meat-juice is eminently unstable, its appearance changing within an hour of its separation, and it develops toxic properties which render it unfit for human consumption. The daily dose is the muscle plasma obtained from 300 to 500 grammes (10 to 17 ounces) of beef, the maximum being given in bad cases. Smaller quantities are beneficial, but cannot be relied on in tuberculosis to give characteristic results. The inconclusive results reported from time to time, according to Héricourt, are due to neglect of these cardinal principles, though it is only fair to add that there are a few cases, usually associated with secondary infection, which prove refractory. The benefits of zomotherapy are not limited to tuberculosis. Raw-meat juice is of the greatest service in the treatment of anæmia, chlorosis, gastric and duodenal ulcer, rickets, scurvy-rickets, neurasthenia, after hæmorrhage, typhoid fever, and whenever it is desired to reinforce the defensive apparatus against the ravages of disease.

There is as yet no clear scientific explanation of the action of raw-meat juice. At the time when Richet and Héricourt carried out their early experiments, the theory of antitoxins had been just elaborated, and it was thought that the action of muscle plasma in tuberculosis was due to an antitoxin. The fact that tuberculosis never invades muscle fibre, but a well-marked atrophy of muscular tissue occurs in phthisical subjects, suggests the possibility that muscle is sacrificed in the defence of the organism. On the other hand, the raw-meat juice or muscle plasma contains enzymes and ferments, which play an active part in nutrition, and especially in the struggle against infective diseases, and may conceivably account for the beneficial results from the ingestion of this fluid. Another explanation is that muscle plasma or raw-meat juice is merely a special stimulant to the nervous system. A slight but characteristic exhilaration always follows the consumption of large quantities of raw-meat juice, and therefore it is possible that the good effects of zomotherapy in diseases other than tuberculosis are due to nervous stimulation. Still another explanation has been offered—viz., that the effects are due to stimulation of the thyroid gland. Cautley says there is evidence that defective thyroid activity predisposes to tuberculous affections; these diseases follow rapid growth, infectious diseases, prolonged lactation, sexual excesses, and alcoholism, in all of which the thyroid secretion is liable to be used up and the gland to atrophy from overstimulation. Thyroid activity is stimulated by raw meat and milk. The infant thyroid contains but little colloid. But it is probable that milk contains some of the internal secretion of the thyroid, for iodine can reach the infant through the mammary gland, and infantile myxœdema rarely develops until after weaning. The decomposition products of raw meat increase the colloid material in the thyroid gland, as was shown in 1897 by Galleotti and Lindermann. Chalmers Watson also found that the consumption of raw meat caused an increase of the thyroids and parathyroids in fowls; but Forsyth

following the same mode of feeding, did not find such increase in the gland.

The Preparation of Raw-Meat Juice.—It should be distinctly understood that heat is not to be applied to the meat, nor to the plasma after it is obtained.

(1) *By Pressure.*—It is prepared on a large scale by hydraulic or steam pressure, the meat yielding about 25 or 28 per cent. of meat-juice or plasma from the flesh of newly killed animals, an example being the **Carnine Lefranc**, a sweet syrupy liquid, which is recommended to be taken cold in any liquid except beef-tea. Various meat-presses are sold for preparing the juice on a small scale, which will express 25 or 30 per cent. of the muscle plasma. In domestic preparation of meat-juice, rump beef-steak is the most suitable source; it is minced, put into a linen wrapper, and submitted to such pressure as can be obtained.

(2) *By Diffusion.*—Rump beef-steak is cut with *scissors* into pieces about ½ inch square and ⅛ inch thick, and put into a basin; a quantity of cold water equal to the weight of meat is poured over it, a small amount of salt is added, and the material allowed to remain in a cold place for six or eight hours. The juice is then poured off and the meat squeezed dry. The juice is a red liquid, and the meat quite colourless when it is properly done. It is usually given in a coloured wine-glass, with an equal quantity of port wine. In many households this is the only form of raw-meat juice obtainable. It cannot be claimed that its therapeutic effects are equal to those of meat-juice obtained by high pressure of meat two or three hours after slaughter; but the effects of this modified meat plasma are truly remarkable in anæmia, chlorosis, gastric and duodenal ulcer, neurasthenia, and even in tuberculosis. The use of fresh meat must be insisted on, as well as keeping it away from the fire. Heat destroys the therapeutic properties of meat-juice. Decomposition of some of the principles in the plasma takes place very readily. Rigor mortis is attended by changes in the myosinogen, a loss of syntonin, and a development of lactic acid; the muscle-juice contains a ferment which transforms glycogen into sugar after death; as the rigor mortis passes off, the myosin again breaks down into myosinogen, the formation of albumoses and peptone occurs, with other products of decomposition, which may set up enteritis, hepatic and renal troubles; and the natural enzymes of the plasma are destroyed.

Milk Diets.—As a "cure" milk, entire or skimmed, sweet or sour, butter-milk, whey, and various other preparations of milk are used.

1. *The milk cure* consists of the consumption of ordinary milk, in its pure, undiluted, and uncooked condition. The milk should be taken fresh and warm, just as it is drawn from the cow. In this condition it is the most free from bacteria, it contains the greatest proportion of enzymes, and has the highest bactericidal capacity. This "cure" is exceedingly ancient, and is of great value in the

treatment of tuberculosis, nervous diseases, and many conditions of debility. The application of the remedy is only possible on a limited scale, and in rural districts, or such places where cattle are kept for the purpose. The cattle should be of a good breed and free from tubercle or other serious ailment. A modified milk cure is that which is usually carried out in hospitals and sanatoria, where the milk is supplied from farms which are often many miles away. It is employed in febrile conditions, in gastric and enteric disorders, neurasthenia, hepatic and renal affections, heart and arterial diseases, arthritic conditions, alcoholism, chronic bronchitis, obesity, and other affections. In these cases also the milk is frequently taken *raw*; but it must not be forgotten that the bactericidal power of milk diminishes rapidly after it is drawn, and a few hours after milking the cows it is practically *nil*. There is, however, the lecithin and small quantities of other bodies to be considered, which are destroyed by heat of 140° F. There are important constituents of milk, and should not be ruthlessly destroyed. If the source of the milk can be depended on; if it is protected from pollution by pathogenic organisms; and if there is no other reason against the consumption of raw milk, such as the formation of curds, raw milk should be taken in preference to any other. When for any reason it is considered undesirable to drink the milk raw, it may be boiled or baked, peptonized or pancreatized, and taken alone or with diluents such as barley-water, oatmeal-water, or lime-water, or its composition may be altered by the addition of extract of malt, dextrin, a small amount of farinaceous material, meat extract, or burnt sugar. In order to supply the body with enough protein and energy on a diet consisting of milk alone, a considerable quantity must be consumed. Milk of average quality has a heat value of 410 calories per pint. If it is consumed in large quantities, digestive derangements very soon occur as the result of the formation of large curds in the stomach; if these pass the pylorus, they are apt to become matted together in the intestines, and thus resist the action of the digestive enzymes, causing diarrhœa or constipation, with hard dry fæces. Rubner[1] found that the undigested material from meat amounts to 4·1 to 4·7 per cent., of eggs 4·7, and of milk 5·4, per cent. Atwater found that with a milk diet 97 per cent. of proteins, 95 per cent. of fat, and 98 per cent. of carbohydrates were absorbed. Other authorities have found as much as 97 per cent. of fat absorbed. Milk, therefore, is one of the most digestible foods; but 3 litres, or a little more than 5 pints, daily, would be required to supply an adult with enough energy for the performance of light work. The nitrogen balance is not maintained by an adult man upon less than 3 litres a day, and when less than this quantity is consumed, most people show a loss of nitrogen.

In the "milk cure" the milk should be given raw, or of the temperature of the atmosphere, and whenever possible it should be conveyed from the cow to the patient as soon as convenient, to

[1] *Zeit. f. Biol.*, xv. 130-133.

avoid the loss of the enzymes and antibodies contained in it. Even in the winter-time it should not be heated above 140° F., because lecithin and other important bodies are destroyed by a temperature higher than this degree. The milk should never be boiled, except when there is diarrhœa, or the source and purity of the milk is doubtful, not only because boiling it destroys the natural enzymes, lecithin, nuclein, and other bodies, but because it is rendered somewhat less digestible than unboiled milk. Listov found the quantitative metabolism of new milk is 91·4 per cent., sterilized milk only 90·4 per cent., and it contains no peptones. Boiling the milk undoubtedly destroys bacteria, and a few years ago it was customary to recommend that all milk should be boiled for a minute or two to destroy them; boiled milk also has the advantage of forming smaller curds than unboiled milk. But in the light of recent knowledge it is considered that pure and wholesome milk should not be heated.

The object of the physician in recommending the milk cure may be not only to maintain the nitrogen balance, but to produce a gain to the body; in other cases it is not the intention of the physician to maintain the nitrogen balance or the nutrition in equilibrium, but to unload the system of superfluous weight, water, purins, or some other substance which is considered to be deleterious. Thus in the Weir Mitchell treatment the object is to cause a gain of protein, and, by means of a "forced diet," to benefit enfeebled nervous and muscular systems. In this treatment the patient is kept in bed and fed for a time entirely with milk, advancing from 2 pints on the first to 4 or 5 pints on the eight-day (*see Weir Mitchell Treatment*). The milk is given in divided doses, 2 to 10 ounces every two hours, day and night, and sipped slowly; the intervals are increased as more milk is taken, and the night-feeding reduced to one meal. When the fæces become small and firm, showing that the milk is being fairly well absorbed, the dose is increased to 10, 15, or 20 ounces per meal, and the intervals extended to three or four hours, so that the total milk amounts to 5 or 6 pints daily.

During the first period of the milk cure—usually two weeks—nothing but milk is allowed, unless it is necessary to alter the flavour or modify its constituents. The flavour may be varied by the addition of salt, celery-salt, the decoction of cocoa nibs, burnt sugar, or extract of malt; the formation of large curds may be prevented by the addition of lime-water, barley-water, oatmeal-water, extract of malt, citrate of soda, etc. Nausea is likewise prevented by these modifications; flatulence may be prevented to a considerable extent by the addition of Vichy water, or a little salt and carbonate of soda; thirst, sometimes complained of, may be relieved by sucking a small piece of lemon, or washing out the mouth after each meal with plain or aerated water, or with acid liquids, such as lemon-water, citric acid, tartaric acid, or cream of tartar and water; or, better still, by a mild germicide, such as a solution of boric acid or glyco-thymoline.

The first part of the milk cure is a period of semistarvation or under-

feeding, for even during absolute rest in bed 1,600 calories of energy are expended daily, which would require the digestion of 4 pints of milk. The subnutrition causes the patient to be sleepless and watchful; the milk causes the tongue to become coated with a thick creamy fur, and there is a nasty taste in the mouth, frequently a considerable amount of flatulence, and sometimes pain from the evolution of hydrogen and other gases. The bowels are confined, and act every two or three days, the fæces being devoid of fæcal odour, and vary in colour from yellow to orange. There may be diarrhœa from casein-indigestion, from excess of fat, or want of freshness in the milk. The urine is usually increased in proportion to the consumption of liquids and the diuretic action of the lactose; it contains very little uric acid and purin bodies, but the urea is in proportion to the digested casein; and the colour often has a greenish tinge. As the consumption of milk increases and the system becomes satisfied, the patient passes from wakefulness to drowsiness, which is a fairly good sign when the tongue is clean and the pulse is good. After two or three weeks, even though the patient is now gaining flesh, the appetite begins to gain strength, and the desire for solid food increases. Now is the time to add to the diet some Benger's or other farinaceous food, with a little stale bread and butter. In another fourteen days a little fish or fowl may be allowed in the middle of the day, and after the end of one month a gradual return to ordinary diet takes place.

2. *Skim milk* is employed as a cure in cases of heart disease, nephritis, gout, obesity, chronic bronchitis and emphysema, and various other diseases. It must be clearly understood that it is a diet which only partially supplies the energy expended by the body; that it is a system of underfeeding,and that there is a definite intention on the part of the physician to reduce the patient more or less. The average composition of skim milk is: water 90·5, nitrogenous matters 3·4, fat 0·3, sugar 5·1, ash 0·7, per cent.; and it has a heat value of *only* 212 *calories per pint.*

In 1865 Karell reported 200 cases in which he had employed this diet as a method of treatment for unloading the system generally, but especially the vascular system. He recommended that at first the milk should be taken only three or four times a day, and later every four hours; the quantity allowed was ¼ to ½ pint of skim milk at each meal, sipped slowly. "Separated milk" can be bought from a dairy, or the milk can be skimmed in the house. The milk should be obtained fresh twice daily. The complete removal of fat is not desirable in all cases; more fat can be allowed to some patients than to others. Donkin had considerable experience in the treatment of disease by skim-milk diet, and highly recommended it for the treatment of diabetes, beginning with 4 pints, and gradually increasing the amount, sometimes to a maximum of 12 pints daily. Lenhartz systematically employed the skim-milk diet for fifteen years in the treatment of heart disease with failure of compensation, chronic bronchitis and emphysema, and obesity with an

overtaxed heart. Roemheld and Moritz have recommended it for obesity, heart disease, gout, and nephritis. But all cases are not treated with skim-milk; pure milk is sometimes used. Under Lenhartz the patient was placed in bed and absolutely at rest; during the first week (or at least five days) he was allowed only 200 c.c. (7 ounces) of milk four times a day; during the next stage, varying from two to six days, he was allowed one egg and some zwiebach; later on some minced meat and vegetables were added; so that after about twelve days there was a gradual return to full mixed diet. Special care must be taken to secure a daily evacuation of the bowels. When the heart has sufficient reserve power, the effect of the treatment is seen in the greatly increased diuresis, loss of weight, and increase of cardiac power or re-establishment of compensation. Failure to obtain relief was considered by Lenhartz to be a sign of advanced degeneration of the cardiac muscle.

Roemheld[1] puts his patients on to a partial milk diet—*i.e.*, milk only on two or three days in each week throughout the cure; on "milk days" he prescribes 1 litre to $1\frac{1}{5}$ litres ($1\frac{3}{4}$ to 2 pints) of milk, and nothing else; on other days he allows a mixed diet to yield from $\frac{2}{5}$ to $\frac{3}{5}$ of the energy expended by the body. The "milk days" are especially effective at the beginning of treatment for failure of compensation. The diet is also suitable for nephritis, gout, and obesity. After the cure, the patient may keep his weight down for an indefinite time if he will continue to have two "milk days" in each week. Moritz recommended the milk cure to be continued for weeks. In his system the food consists of milk alone; and the amount allowed varies from $1\frac{1}{4}$ to $2\frac{1}{2}$ litres (2 to $4\frac{1}{2}$ pints) daily; He claims that this is the simplest cure for obesity, that the patient loses an average of 200 grammes daily without suffering from thirst or hunger, and as a rule can go about his work during the treatment, but requires to be under observation. Strauss[2] also employs the milk cure for obesity of moderate and severe grades, and recommends a tumblerful of milk to be taken four or five times a day at intervals of $2\frac{1}{2}$ hours *for about a week;* after this time the patients are given less milk but are allowed small quantities of lean meat, sausage, vegetables, and bread, but *no fat;* in a few cases the milk is now stopped and a mixed diet of low calorie value is prescribed. Strauss does not agree with Roemheld's system of treatment by "milk days"; but considers it is better in medium cases of obesity, complicated by heart lesions, nephritis, gout, or glycosuria, to prescribe a "miniature cure" of three or four days' duration, with rest in bed and massage. The loss of weight is greatest during the first three days, and averages $4\frac{1}{2}$ to $6\frac{1}{2}$ pounds, but by the end of the week the total loss is from $8\frac{1}{2}$ to 11 pounds; during the after-cure the loss of weight is more gradual than in the actual "cure." There is little doubt that the loss of weight is partly due to underfeeding; but it is also due in part to the loss of water by the tissues. In a

[1] *Monats. f. d. physik. diätet. Heilmethoden*, January, 1909.
[2] *Wien. Med. Klinik.*, March 27, 1910.

large proportion of cases the patient's increase in weight is due to the retention of water in the tissues, and this retention is due to the presence of chloride of sodium. With a milk diet (always assuming that no salt is added to the milk) the system loses more chloride of sodium than is taken up, and the loss of fluid by the tissues is due to the diminution of sodium chloride. Strauss found that every 6 grammes (92·5 grains) of sodium chloride excreted meant a loss of about 1 litre (35 ounces) of water from the tissues. Belli found that after the conclusion of the "cure" some patients put on weight when they returned to a mixed diet even of low calorie value, which he attributes to the fact that there is a partial retention of sodium chloride as soon as the patient begins to take the ordinary condimental quantity; and therefore such people should be forbidden to eat more than a minimum amount of salt with their food.

3. *Partial Milk Diet.*—There are several interpretations of this phrase—*e.g.*, the "milk days" of Roemheld form a partial milk diet; the ordinary sick diet consisting of milk, eggs, beef-tea, jelly, etc., is also a partial milk diet. A partial milk diet is also that which includes the addition of 1 or 2 pints of milk to an ordinary mixed diet. This is probably the best treatment for a very large proportion of all cases of mal-nutrition, neurasthenia, general debility, and phthisis. Two pints of milk daily, added to the ordinary food, is the usual amount prescribed, but more may be taken if the patient can consume it. In very many cases the patient cannot consume more than 2 pints, and an attempt to force it upon them results in their refusing their meals, which the milk is intended to supplement and not to replace. Most patients, however, can take porridge and milk, besides milk-tea, milk-coffee, or milk-cocoa for breakfast, a tumblerful of milk at 11 a.m., another between 3 and 7 p.m., and a final one at bedtime.

4. *The Whey Cure.*—Whey is the liquid which remains after the precipitation of casein by rennin, as in cheese-making. It is a thin, almost transparent, liquid of a pleasant sweetish taste. It contains 1 to 1·25 per cent. of proteins (casein and albumin), 0·3 to 0·5 per cent. of fat, and 3·5 to 5·0 per cent. of sugar, with the ordinary salts of milk, including CaO 0·5, and P_2O_5 0·103, per cent. According to Atwater, *the heat value is only* 156 *calories per pint.* It has always been considered a nutritive beverage, useful in the treatment of disease, and as a diluent of cow's milk for feeding infants. It is easily digested, is usually bland and unirritating to the stomach, but it may cause flatulence and acidity in people who are subject to those troubles, and it causes infants to have green stools. It is diuretic in proportion to the percentage of lactose. It is useful in the treatment of abdominal plethora, and the catarrhal conditions of the alimentary canal common to it; also for bronchial or laryngeal catarrh, renal and dropsical affections, jaundice, enteric fever, and other febrile ailments.

Whey is easily obtainable from cheese-factories during the season, but at other times, and at a distance from such a source, it is pre-

pared on a smaller scale. The milk is warmed to not more than 104° F., rennet, rennet powder, liquid rennet, or a solution of commercial junket tablet is added in the proportions directed on the label, just as in the making of junket. It is sufficiently coagulated in thirty minutes; the coagulum is then broken up with a fork and strained through muslin; 1½ pints of milk will yield 1 pint of whey, which contains rather more protein and fat than that obtained in the process of cheese-making.

The whey cure is carried out at Ems, Ischl, Reichenhall, and other places, where a pint of whey is given daily in combination with a mixed diet of low calorie value, in which the animal foods are reduced and vegetable foods increased. Many of the cases treated by the whey cure in these places could be treated in the same manner at home. It has been recommended that the patient should begin by taking a tumblerful of whey morning and night, and increase the amount by one tumblerful each day until ten tumblerfuls are consumed. It may be taken warm or cold, or aerated by the addition of a small proportion of seltzer or soda water, or put into a seltzogene and aerated with a cartridge of CO_2. It has been recommended as a sole diet in typhoid fever, in doses of 6 ounces every two hours. Many cases of typhoid fever end fatally owing to their inability to digest milk, to intestinal fermentation and distension, which are said to favour hæmorrhage and perforation. Cautley considers that such consequences never occur when the diet consists only of whey, the passage of undigested food being prevented and distension being very rare; and, when digestive troubles occur in the course of typhoid fever, the adoption of a whey diet will relieve them. It is only necessary to point out the extremely low calorie value of whey to show that it is unsuitable as a sole diet for any length of time; that during absolute rest in bed the body expends at least 1,600 calories, which could only be supplied by the consumption of 10 pints of whey per diem. The use of whey as a diluent of cow's milk is very useful in many cases of illness, and especially in the gastric and intestinal affections of infants, and in ordinary feeding of children.

5. *Buttermilk* has also been used as a "cure" for the same diseases as are treated by the whey cure. It is the liquid which remains behind after the manufacture of butter from ripened cream—that is, cream which is not less than twenty-four hours old. According to Atwater, the average composition of buttermilk is—Water 91, nitrogenous matters 3, fat 0·5, sugar 4·8, salts 0·7, per cent., and it has a heat value of 201 calories per pint. The composition, however, varies, and the heat value varies correspondingly. According to Blyth, Richmond, Salge, and others, the protein ranges from 2·5 to 3·8 per cent., the fat from 0·5 to 1·25 per cent., the sugar from 3 to 4·8 per cent., and the heat value from 170 to 265 calories per pint. Buttermilk can be made on a small scale by means of a centrifuge, the cream being heated to 60 or 70° F., and agitated in it for fifteen minutes. A small glass churn of 2 or 3 pints' capacity may be

used. It is a pleasant fluid of subacid taste, containing milk sugar, casein in a finely divided condition, and lactic acid as well as lactic acid bacilli. It can be consumed at one meal or in tumblerfuls during the day, the unconsumed buttermilk being kept in a cold place or on ice. When it is taken *raw*, the lactic acid and its bacteria are both consumed, and the casein forms very fine flocculi, which are acceptable to the stomach. Buttermilk is suitable as a beverage in febrile conditions, as a cure in plethoric conditions, also in gastro-enteritis and other intestinal disorders, for which the high degree of acid is beneficial; and it is especially suitable to assist in the feeding of infants during the summer-time, when the stools are sour and foul, in green diarrhœa, and after recovery from acute diarrhœa. **Nutricia** is condensed buttermilk sold under that name, and is of value when fresh buttermilk cannot be obtained.

6. *The Sour-Milk Cure*.—Milk freshly drawn from the cow is amphoteric, the acid sodium phosphate in it turning neutral litmus red, and the alkaline sodium phosphate turning it blue; but the reaction becomes more and more acid on exposure to the air, owing to the development therein of various acid-producing bacteria. These bacteria are not exactly normal to the milk, but it is practically impossible to draw milk from a cow which is perfectly free from them; they exist in the galactiferous ducts, and are always present in the atmosphere of the byres, and commonly present in that of houses. The chief of these bacteria is Hueppe's lactic acid bacillus, an organism 1μ long and $0{\cdot}004\mu$ broad. It multiplies rapidly in milk at a temperature between 10° and 45° C. (50° to 113° F.); and by means of enzymes, *lactase* and *endolactase*, it transforms the lactose into lactic acid. The multiplication of bacteria and production of acid goes on until the lactic acid reaches the proportion of 1 to 1·5 per cent. When the maximum production is reached, the growth and multiplication of the bacteria ceases, owing to the bactericidal power of lactic acid. In the meantime, the milk becomes sour, and coagulates spontaneously with the formation of a solid mass of casein which gradually contracts and squeezes out the whey in the form of a greenish-yellow fluid. Hueppe's bacillus, though the most common one, is not the only micro-organism which produces lactic acid and turns the milk sour. Other lactic-acid-producing organisms have been described by Hueppe, Krueger, Massol, Weigmann, Grotenfelt, and Markmann, including bacilli, micrococci, streptococci, and staphylococci, and several of these organisms were found to exist simultaneously.

The sour-milk cure is exceedingly ancient, but it is probably not so ancient as sour milk as a food. In Russia, Tartary, Bulgaria, Roumania, Turkey, Arabia, and Egypt, various forms of sour milk have been used for food from time immemorial. In Scotland sour milk is frequently consumed with porridge. In some parts of the United States sour milk, or clabber, is commonly eaten. Several forms of sour milk have special names and are prepared in a particular manner, instead of the spontaneous souring which is common

to all milk. Some of the most common forms are as follows: **Koumiss** is the fermented milk of mares and asses, used extensively by the inhabitants of Russia and Tartary. **Kephir** is the fermented milk of cows or goats, and is likewise extensively used by the inhabitants of the Caucasus. **Yaourte** (youghourt), or leben, is the fermented cow's milk commonly eaten all over the Levant, Egypt, Arabia, and adjoining countries.

Home-Made Sour Milk.—Sour milk, having somewhat the characteristics of yaourte, or leben, can now be prepared in the home. Numerous cultures of the Bulgarian bacillus and others are sold commercially in the form of tablets and liquids, which have trade names. Many of them are exceedingly useful, and, being prepared from pure cultures of the bacteria, are guaranteed to be free from undesirable organisms. The following table shows the average composition of various forms of sour milk, derived from analyses by Hammarston, Fleischmann, Hartier, Sharp, Stange, Dujardin-Beaumetz, Wanklyn, Richmond, etc.:

COMPOSITION OF SOUR MILK—PERCENTAGES.

Composition.	Kephir: Goat's Milk.	Koumiss: Mare's Milk.	Egyptian Youghourt: Cow's Milk.	Home-Made Koumiss: Cow's Milk, Sugar, and Yeast.	Home-Made Youghourt: Cow's Milk and Cultures of Bacilli.
Water	87·33	89·19	47·44	88·00	89·00
Casein	2·75	1·73	16·00	2·56	3 to 3·25
Albumin	·46	·55	3·76	·32	
Peptones	·26	·25		·25	·25 to ·46
Fat	3·08	2·05	16·00	1·25	3·0 to 3·5
Sugar	2·56	2·25	14·00	3·67	1·25 to 2·0
Alcohol	1·75	1·50	—	1·60	·21
Lactic acid	1·25	1·15	2·25	·61	·5 to 1·0
Carbonic acid gas ..	·65	·75	—	1·50	1·0 to 1·25
Salts	·56	·26	2·80	·75	·20

Sour-milk preparations are valuable as foods in proportion to their content of protein, fat, and carbohydrate. The protein is partially digested by the enzymes, the total amount being about the same as in milk. Alexeyer analyzed the composition of the proteins in cow's milk and kephir made from it; the proteins of milk consist of casein 87·3, albumin 8·2, and hemialbumose 4·5, per cent.; those of kephir consist of casein 81·68, albumin 3·02, acid albumin 6·73, hemialbumose 7·84, and peptones 0·83, per cent. In consequence of these changes, kephir is more easily digested than cow's milk. Some of the fat is split into fatty acids, butyric acid appearing among them. Mare's and ass's milk contain less fat than cow's milk, and for that reason are better digested. Part of the sugar is transformed into lactic acid. Kephir, therefore, is nutritive, but not to the same extent as milk; it is diuretic and laxative, but pre-

vents intestinal putrefaction by means of its lactic acid and bacilli; it is mildly stimulating by virtue of the small proportion of alcohol; the carbonic acid gas is a sedative to the mucous membrane of the stomach, but encourages gastric secretion.

Koumiss and kephir are nutritive in proportion to their contents. Atwater found that when prepared from cow's milk and sugar they contain protein 2·8, fat 2·1, sugar 5·4 (including cane-sugar 4·4), and alcohol 0·76, per cent.; and have a heat value of 240 calories per pound, or 300 calories per pint. The casein is precipitated in fine flakes, being partly converted into peptones and proteoses, and is easily digested. The lactic acid augments the digestive powers, regulates mucous secretion, and increases diuresis. The small amount of alcohol promotes the assimilation of fat, gives heat, and at the same time tends to lower the temperature and encourage sleep. The carbonic acid gas allays nausea, calms gastric irritation, increases the flow of urine, diminishes the frequency of the heart, and at the same time augments its force. These forms of fermented milk are useful as an aid in the treatment of phthisis, tuberculosis, chronic gastric catarrh, chronic intestinal catarrh, colitis, ileo-colitis, auto-intoxication, diseases of the hepatic, urinary, and nervous systems; also in anæmia and other forms of malnutrition.

The koumiss or kephir "cure" is carried out in various establishments in and about Ssamara and other places in the Steppes of Orenberg. In these institutions an ordinary allowance of koumiss is 7 pints (4 litres) per diem. The patients rise early and take a glassful of koumiss every half-hour throughout the day, excepting for two hours before dinner and supper. The amount of nutriment contained in 7 pints of koumiss made from cow's milk would be 112 grammes of protein, 84 grammes of fat, 216 grammes of carbohydrate, and 30 grammes of alcohol, and would yield 2,100 calories. The same amount of kephir from goat's milk would yield about 2,500 calories; it is therefore a large contribution to the dietary. At first, however, only a few glassfuls of kephir or koumiss per day are allowed until tolerance is established, because of its tendency to cause diarrhœa, which may require the addition of lime-water to check it. It is well and easily assimilated, but only one case was found by Alexeyer in which kephir alone was sufficient to maintain the nitrogenous metabolism, and that was a healthy young man who consumed only 5¼ pints daily for two days. During the "cure" the rest of the diet consists of meat and fat; carbohydrates, especially sweets, ices, fruit, vegetables, salads, coffee, and spirits are excluded. The amount of koumiss or kephir prescribed, added to a concentrated diet of protein and fat, together with an out-of-door life in the bracing air of the Steppes, must be advantageous to many cases of early phthisis, tuberculosis, insomnia, nervous affections, gastro-intestinal and hepatic diseases, and various forms of malnutrition. The severity of the winter in these regions would preclude many Europeans from going there at that period of the year; but the success of treatment at high altitudes in other parts

of the world is a recommendation in favour of it. Home treatment by koumiss or kephir can be carried out on the same lines.

Nitrogen-free Diet (full and modified).—A nitrogen-free diet can be made of starch, sugar, salt, and almond-oil or other fat; these articles can be made into a palatable cake, leavened with baking-powder. Plain water or spirit and water can be taken as a beverage. There is at present no therapeutic use for a nitrogen-free diet, nor is it conceivable that it could be taken for any length of time. It has been used chiefly for experimental purposes, especially when making observations on the metabolism of nitrogen. When a man consumed a nitrogen-free diet for three days, Lehmann found that he excreted daily 7·4 grammes of nitrogen. In a similar experiment lasting eleven days, Reider found that the average excretion of nitrogen in the urine was 8·7 grammes, and the fæces contained 0·9 gramme, which was equivalent to a loss of 56 grammes of protein daily. It is unknown how much "floating protein" there is in any human organism; it varies from day to day; but it may be assumed that all the floating protein would be consumed in a few days, and after three or four days the excreted nitrogen would arise from the destruction of "tissue-proteins," which is seldom or never desirable. There is a physiological minimum to the amount of nitrogen required daily, and it is not safe to continue to take food containing less than that amount, otherwise the muscular tissues must waste.

If it should ever be considered advisable to clear the system of "floating protein," it may be done by giving a comparatively nitrogen-free diet for about four days. The diet might be selected from foods containing less than 0·5 per cent. of protein—*e.g.*, arrowroot-starch, corn-starch, sugar, honey, and oil such as sweet almond or cottonseed oil; or from foods containing 0·5 to 1·0 per cent. of protein, such as manioc-starch, arrowroot, sago, tapioca, apples, pears, rhubarb, melon, musk-melon, plums, raspberries, strawberries, gooseberries, oranges, lemons, tomatoes, cucumber, radishes, turnips, carrots. The following foods contain from 1 to about 1·5 per cent. of protein: grapes, bananas, leeks, onions, cabbage, cauliflower, parsnips, rutagagas, pumpkins, squash, sauerkraut, celery, pickles, horseradish, tomato-catsup; margarine contains about 1·2, butter 1 to 1·5,a nd suet a minimum of 1, per cent. Asparagus contains 1·8, potatoes 2, string or kidney beans 2·3, and artichokes 2·6, per cent. Lard contains 2·2, thick cream, 2·5, *fat* salt pork 2·0, ham fat 2·8, and bone-marrow 2·3, per cent. of protein. Spirits contain no protein, and the amount in wine is practically negligible, and an infusion of cereal coffee (1 in 20) contains only 0·2 per cent. of protein. The choice of foods is large, and such a diet, while yielding sufficient energy, would speedily result in a clearance of superfluous protein materials. After taking a diet consisting of the foregoing fruits and vegetables for four days, some bread, rice, oatmeal, milk pudding, or soup, may be added to the list. The amount of protein in these foods is as follows: Beef

soup 4, meat stew (when meat is taken out) 4·6, oxtail soup 4·0, chicken broth 3·6, tomato soup 1·8, vegetable soup 2·8, milk 3·5, *boiled* rice 2·8, *boiled* oatmeal (thick) 2·8, brown bread 5·5, white bread 8 or 9, zwiebach 9·8, per cent. The return to the ordinary diet, or one containing at least 55 grammes of protein daily, should not be deferred longer than the eighth day.

Purin-free Diet.—The purin bodies are nitrogenous substances which contain the group C_5N_4; they include uric acid, xanthin, hypoxanthin, adenin, guanin, and methyl-xanthin (caffein and theobromin). These bodies arise from nucleo-proteins, which are normal constituents of the nucleus and protoplasm of cells. In the animal system the nucleo-proteins are split into nuclein and protein; the nuclein is again divided into nucleic acid and protein; and the nucleic acid into purin bodies, phosphoric acid, etc. This is the normal order of metabolism of nucleo-proteins, and it occurs in animals as well as human begins. Consequently purin bodies exist ready-formed in many of our foods, especially those of the animal kingdom.

The synthesis of purins begins in the embryo, and was studied by Mendel during the incubation of eggs. Beginning with fresh eggs, *free from purins*, he found that the quantity of purins increased gradually during the incubation period until they were hatched. The specific purins synthetized as part of the newly formed nucleo-protein are guanin and adenin. The process of purin-formation goes on throughout life as a part of the cell metabolism, but the transformation of purins likewise goes on constantly. A number of enzymes co-operate in the transformation of the purin-containing materials. Thus, nucleases liberate guanin and adenin from nucleic acids; amidases convert these amino-purins into xanthin and hypoxanthin respectively; and oxidases transform hypoxanthin to xanthin, and then to uric acid; and the latter is finally decomposed by uricolytic enzymes present in various organs.

It is evident, therefore, that certain purin bodies are constantly being produced wherever cellular processes are in active operation, and although these are normally converted into other materials which are more easily excreted, all animal foods must contain some of them. *Lean meat*, the flesh of mammals, birds, and fish, contains xanthin, hypoxanthin, and uric acid, besides urea, creatin, creatinin, and other extractives. *Liver* is rich in nuclein, xanthin, hypoxanthin, uric acid, urea, and all other nitrogenous extractives. *Spleen* (milt) also contains nuclein, xanthin, hypoxanthin, uric acid, lecithin, creatinin, leucin, and tyrosin. *Thymus* (chest sweetbread) contains nuclein, xanthin, hypoxanthin, guanin, and adenin in excess. *Pancreas* (belly sweetbread) contains the same kinds of purins, besides leucin, tyrosin, and other amino-acids. *Kidneys* contain urea, uric acid, xanthin, hypoxanthin, taurin, leucin, creatin, creatinin, etc. Beef-tea, soup, and gravy contain the same kinds of purins and extractives as the substances from which they are derived. *Vegetable foods*, especially seeds, contain nucleo-proteins, nuclein, nucleic acid, and purin bodies, with amino-acids such as

asparagin, leucin, tyrosin, etc. Tea, coffee, and kola contain caffein or trimethyl xanthin—that is, xanthin with three methyl groups in its molecule; cocoa contains theobromin or dimethyl xanthin; and guarana contains both caffein and theobromin.

The purins which are consumed with the food are called *exogenous* purins. But every healthy individual excretes a certain characteristic amount of purins which is independent of the food. This is the result of the metabolism of his own tissues, and hence is called the *endogenous* purins. The amount of purins excreted in the urine due to endogenous formation may be estimated after taking a purin-free diet for a few days; and it varies in most people from 0·1 to 0·2 gramme daily.[1] Of this amount 50 per cent. is transformed, mainly into urea by the liver, and 50 per cent. is eliminated unchanged—*i.e.*, as uric acid, xanthin, hypoxanthin, etc., by the kidneys. The exogenous purins are also partly transformed in the body, 50 per cent. being excreted as urea, the remaining portion being excreted by the kidneys as xanthin, hypoxanthin, uric acid, etc.

On ordinary diet the excretion of purins is necessarily increased by the exogenous or nutrition purin. According to Burian and Schurr, all the exogenous purin does not pass out of the body, a fraction remaining in the organism or becoming entirely broken down by oxidases in various organs. The amount of exogenous purin in the urine is but little influenced by the individuality of the subject. Given the same kind and amount of food, the purin excretion is practically the same in normal individuals; but it is much influenced by the kind of food. Burian and Schurr found the purin bodies in beef and veal to be 0·16, calf's liver 0·12, calf's spleen 0·16, calf's thymus 0·4, and coffee 0·2, per cent.; and when eaten alone, they caused an excretion of exogenous purin in the following proportion: Beef and veal 0·03, liver 0·06, spleen 0·8, thymus 0·1, and coffee 0·075, per cent.[2] Walker Hall has given special attention to the purin bodies. He gave an estimate of the amount in various foods (see table on p. 226).[3]

It is clear, however, that all the purins in the food are not absorbed. Although Burian and Schurr found that, with the same amount and kind of food, the exogenous purin in the urine is practically the same in all persons, there is a personal equation in the matter, as Walker Hall found, with regard to absorption. There is a normal daily excretion of purin bodies in the fæces, called the *fæcal purin*, to distinguish it from that excreted by the kidneys, called the *urinary purin*. The amount of fæcal purin varies with the kind of food, and is greater where substances are eaten which are rich in nuclein and purin derivatives: thus, when a person consumed 500 grammes of sweetbread, 60 per cent. of the purin bodies were absorbed and 40 per cent. voided in the fæces. The amount of nitrogen excreted daily in the fæces on an ordinary diet is about 1·39 grammes daily, of which 0·9 gramme is due to metabol-

[1] Burian and Schurr, *Pflüger's Archiv*, 1900, 80.
[2] *Loc. cit.* [3] *Brit. Med. Jour.*, 1902, i. 1461.

ism of the tissues, and the remainder from the residue of the food. Given the same diet, the same individual normally excretes the same amount of purin bodies in the fæces daily. This has to be estimated in experiments upon metabolism, but clinically small variations are generally neglected. The amount of purin in the fæces may be increased in diarrhœa and intestinal catarrh by shedding the cells of the mucous membrane; similarly there may be a slight increase in the output of purins owing to loss of nuclein in bronchial and pharyngeal catarrh, and purulent conditions of the lungs, and in catarrh of the bladder. But the remaining tissue cells pass all their nuclein derivatives into the circulating fluids of the body, reaching the liver in the usual way, and are the chief source of the endogenous purin formation.

THE QUANTITY OF PURINS IN FOOD.

Food.	Per Cent.	Grammes per Kilo.	Grains per Pound.
Cod-fish	·058	·58	4·07
Plaice	·079	·79	5·56
Halibut	·102	1·02	7·14
Salmon	·116	1·16	8·15
Tripe	·057	·57	4·00
Mutton	·096	·96	6·75
Veal: Loin	·116	1·16	8·14
Pork: Loin	·121	1·21	8·49
Neck	·056	·56	3·97
Ham (fat)	·115	1·15	8·08
Beef: Ribs	·113	1·13	7·96
Sirloin	·130	1·30	9·13
Steak	·206	2·06	14·45
Liver	·275	2·75	19·26
Sweetbread	1·006	10·06	70·43
Chicken	·129	1·29	9·06
Turkey	·126	1·26	8·82
Rabbit	·097	·97	6·31
Oatmeal	·053	·53	3·45
Peameal	·039	·39	2·54
Haricot beans	·063	·63	4·16
Potatoes	·002	·02	·14
Onions	·009	·09	·26
Asparagus	·021	·21	1·50
Lager beer	·012	·12	1·09
Pale ale	·014	·14	1·27
Porter	·015	·15	1·35

All cell metabolism is attended by changes of a destructive character. Carbon is oxidized, and forms carbon dioxide, hydrogen unites with oxygen to form water, nitrogen is burnt off, but only partially reduced. Urea is the chief product of protein metabolism, and it is formed principally in the liver, but it is very probable that other cellular organs, such as the spleen and lymphatic glands, participate in its formation. Creatin, one of the chief products of

muscular metabolism, is considered an important intermediate body in the formation of urea. Uric acid is regarded as another of the intermediate bodies, and this is supported by the fact that urea can be artificially produced from uric acid. The amino-acids, leucin, tyrosin, glycocin, etc., are also considered to be intermediate bodies in the formation of urea, and the thesis receives support from the fact that the amount of these amino-acids in the urine is increased in acute yellow atrophy of the liver.

Uric acid, next to urea, is the most important nitrogenous material excreted by mammals, and yet the amount only reaches 0·5 to 0·75 gramme per diem. It is the chief nitrogenous excretion in birds. Roberts considered its presence in mammalian urine an anomaly, its place being taken by urea, which is better adapted to the liquid urine of mammals; uric acid in mammalian urine is therefore regarded as a vestigial remnant of descent, and its excessive formation a retrograde process. Uric acid and its salts (urates) are the chief excretory products of birds and reptiles, apparently because it is more convenient for them to pass a solid urine. It is essential for mammalia to excrete water by means of the kidneys, and, as urea is a more soluble material than uric acid, it is better suited as an excretory product to the mammalian type. It is an adaptation of means to an end. There are two chief views of the origin of uric acid: (1) That it is formed in the kidneys, (2) that it is formed in the tissues. The view that uric acid is formed in the kidneys, as well as excreted by them, is chiefly supported by Garrod. That uric acid is formed in the tissues is the view held by most authorities, and this is considered proved by the fact that there is always a little uric acid in the blood, liver, spleen, lymphatic glands, and other organs; that most uric acid is excreted when the liver and spleen are most active; that the excretion is diminished, and it accumulates in the blood and tissues in gout; and that it continues to be formed after the removal of the kidneys.

Whatever interferes with the formation of urea by the liver will cause an increase in the amount of purins *per se* which have to be excreted, as normally half the purins are transformed into urea by the liver, and the other half excreted as purin by the kidneys. Whatever interferes with the excretory function of the kidneys will lead to a retention of purins in the body. Whatever causes a reduction of the oxidative processes in the body will interfere with the reduction of the purins in the tissues to less noxious forms of excretory products. The persistent consumption of foods containing a large percentage of purin bodies is apt to lead to their accumulation in the organism. So long as the liver can transform and the kidneys excrete purin bodies, no harm, it may be thought, will follow. But a constant irritation of the kidneys by an excess of purins, especially uric acid, may result in chronic nephritis of the gouty variety, with other evidences of chronic gout. The retention of purins in the system is amongst the recognized causes of gout, rheumatic gout, uric acid gravel, uric acidæmia, migraine,

neuralgia, sciatica, epilepsy, vascular diseases, and many other conditions of ill-health.

In this group of diseases the treatment frequently includes the use of a *purin-free diet.* The following foods practically *contain no purin :* Milk, cheese, cream, butter, eggs, white bread, macaroni, rice, sago, tapioca, cabbage, cauliflower, lettuce, watercress, fruit, sugar, honey, marmalade, jam, sherry, port, volnay, and claret. It is a milk and fruit diet, with bread-and-butter, milk puddings, and salads added to it. Strictly speaking, milk and its derivatives contain traces of purin. Potatoes and onions contain very little, and are allowed. Oatmeal, peameal, and malted lentils contain only 2·5 to 3·5 grains per pound. Tripe, cod-fish, plaice, and neck of pork contain only 4 or 5 grains per pound, and they are aften allowed in small quantities. Asparagus contains little purins, but much asparagin, which is a valuable protein-sparer. Peas, beans, and lentils only contain 4 or 5 per cent. of purins, but they also contain nucleo-proteins which are converted into purins in the body. The following articles are usually forbidden altogether: Tea, coffee, cocoa, kola, guarana; fish, fowl, and butcher's meat; brown bread (wholemeal bread), peas, beans, asparagus; ale, stout, and lager beer. Water and milk are allowed; buttermilk, whey, koumiss, kephir, cider, perry, and a small quantity of spirits, claret, sherry, or volnay, may also be allowed unless they are contra-indicated on other grounds than the presence of purins.

Fat-free Diet.—It has been recognized for a long time that the presence of an excess of fat, and especially butter, in the contents of the stomach will check the secretion of gastric juice; and advantage is taken of this fact in the treatment of hyperchlorhydria. Conversely, the absence of fat from the food allows a more generous secretion of gastric juice, including hydrochloric acid. In various gastric ailments there is a condition of hypochlorhydria—that is to say, the normal proportion of hydrochloric acid is not present. In consequence of the diminution of free hydrochloric acid, the mucous membrane of the stomach becomes infected by micro-organisms, which give rise to catarrh, organic acidity, atony of the muscular coat, and dilatation. The proportion of free hydrochloric acid in the gastric juice is likewise diminished in carcinoma wherever it may be situated; and it is considered by some authorities that the cachexia produced by this disease is a consequence of the subnutrition resulting from hypochlorhydria.

It is obvious that no antiseptic mixture could be given which would penetrate to all the folds and crypts of the mucous membrane. But hydrochloric acid is serceted by the mucous membrane; it is a valuable antiseptic, and is more active in its nascent form than when administered as a drug. It is argued, therefore, that the removal of fat from the food encourages a freer secretion of gastric juice, that such juice contains a greater proportion of free hydrochloric acid, and that the nascent acid comes first into contact with the crypts of the mucous membrane, which it slowly but surely

disinfects, while at the same time it gives tone to the muscular coat. A fat-free diet, therefore, must be of value in hypochlorhydria, catarrh, atony, and dilatation of the stomach, and in carcinoma of the stomach and other organs.

Fat-free foods are sugar, honey, treacle, starch, dextrin, beef-tea, meat extracts, casein preparations, the white of eggs, and a few others. It is almost impossible to provide an absolutely fat-free diet, nor is it conceivable that such a diet would ever be essential. But we can approximate to it by removing as much fat as possible from the meat and milk, and avoiding the use of butter, suet, and other fats and oils. The diet may be selected from the following list, many of the foods containing less than *one-half* per cent.:

Foods containing 0·5 *per cent. or less:* Skim milk, casein powders, sugar, corn-starch, arrowroot, sago, tapioca, green peas, string beans, potatoes, parsnips, carrots, turnips, radishes, beetroot, salsify, scorzonera, cabbage, cauliflower, brussels-sprouts, spinach, vegetable marrow, squash, asparagus, tomatoes, mushrooms, truffles, onions, leeks, celery, lettuce, watercress, cucumber, rhubarb; apples, pears, peaches, plums, strawberries, raspberries, gooseberries, currants, melons, musk-melons, water-melons, oranges; litchi nuts; and *the white of eggs.*

Foods containing less than 1 *per cent. of Fat:* In addition to the foregoing—fine white flour, white bread, ryemeal and rye bread, beef-tea, meat extracts, beef broth, meat stews when skimmed, tomato soup, oxtail soup, mulligatawny soup, pea soup, gumbo soup. Turtle, frog's legs, oysters, clams, scallops, crab, crayfish, shrimps. Fish: bass, cod, cusk, flounder, haddock, hake, yellow perch, perch-pike, grey pike, pickerel-pike, pollock, red grouper, and red snapper.

Foods with 1 *to* 2 *per cent. of Fat:* Sole, plaice, smelt, sturgeon, weak-fish, skate, blue-fish, black-fish, king-fish. *Venison,* partridge, breast of boiled fowl; wheat, brown bread, wholemeal bread, buckwheat flour, macaroni, vermicelli, haricot and navy beans, dried peas, frijoles, green corn; grapes, bananas.

The food, therefore, should consist largely of bread, treacle, marmalade; white of eggs, meat extracts, soups, broths, mushrooms, oysters, light fish, lean meat, fowl or partridge, potatoes, vegetables, and fruits. All substances containing the meat bases or extractives provoke the secretion of gastric juice. Fatty foods and spices are to be avoided.

Carbohydrate-free Diet.—A diet free from starch, sugar, and other carbohydrates is recommended for the cure of gastric ailments, rheumatism, gout, diabetes, uric-acidæmia, and various other ailments. The usual form is that of the Salisbury diet—meat, green vegetables, and hot water—which has been discussed under the head of meat cures. A strict diabetic diet answers very well as a carbohydrate-free diet, and will be found under Diabetes.

Salt-free Diet.—It has been observed that certain pathological conditions are more readily improved when common salt is with-

held from the diet, and reports thereon have been made for some years. The conditions in which it has been found most beneficial to withhold sodium chloride are dropsy from cardiac, renal, or hepatic diseases, various other forms of œdema, pleuritic effusions of a non-febrile character, obesity, diabetes insipidus, and epilepsy.

In prescribing a limitation of the intake of salt it is not intended to make the rule absolute. Sodium chloride is essential for the proper discharge of the metabolic functions. The adult human body normally contains about 200 grammes of it. It is an important food, as well as a condiment, for something like 15 or 20 grammes leave the body daily in the urine, and small quantities in the perspiration and fæces. The presence of chloride of sodium in the food facilitates the absorption of proteins, and assists in the metabolism of the same. During early life sodium salts are much used in the growth of the cartilages, and are of more importance as tissue-formers at this period than in adult life. But it cannot be done without, for if potassium chloride be substituted for the sodium salt, various disturbances arise from deficiency of the latter. The tissues, however, retain sodium chloride very tenaciously, and when it is withheld from the food, very little passes out by the kidneys. It is possible that under certain conditions the faculty of retaining sodium chloride is abnormally pronounced, and the presence of an undue amount of salt in the system leads to pathological conditions, the undue retention of the salt being a sign of enfeebled metabolism, and is believed to be a cause of œdema and dropsy.

It is estimated that the average consumption of salt amounts to 15 or 20 grammes a day, and corresponds to the amount excreted by the kidneys. It is undesirable that the food should be absolutely salt-free, and it is almost impossible to prepare food quite free from it. The following table of the percentage of sodium chloride in raw and cooked foods is chiefly from an article by H. Strauss on the best method of reducing the amount of salt in the diet:[1]

CHLORIDE OF SODIUM IN FOOD.

Raw Foods.	Per Cent.	Cooked Foods.	Per Cent.
Unsalted butter	·02	Poached eggs	·5
Yolk of eggs	·02	Fruit, usually less than	·5
Fruit, not more than	·06	White bread	·48-·07
Meat, unsalted	·10	Brown bread	·75
Vegetables and salads	·10	Cauliflower	·5-·9
Cereals and legumes	·01-·10	Cabbage	·5-·9
Milk	·15-·18	Mashed potato	·5-1·0
Eggs	·14	Roast beef	1·9-2·8
White of eggs	·19	Beef steak	3·0
Salted butter	1·00	Buttered eggs	2·4
Cheese	1·5-2·5	Omelettes	2·7
Caviar	6-7	Asparagus	2·7-3·5

Common salt used to be regarded as an indifferent substance, but Javal and Widal showed that a retention of 10 grammes of sodium

[1] *Zeit. f. Phys. u. Diät. Therap.*, April, 1908.

chloride was capable of producing œdema. It has been shown that if the quantity of salt is reduced to a minimum, the osmotic pressure of the fluids in the vessels and tissues increases, and œdema is reduced. It is unknown how far the increased absorption of water after taking a larger quantity of salt than usual is physiological and how far it may be pathological. Mendel[1] considers there is a hydræmic plethora, as distinguished from true plethora, by which he means an increase in the amount of water in the tissues beyond the normal limit. Evidence of such a condition is found in the observations of Cohnheim and Lichtheim. But the experimental evidence as well as clinical facts tend to show that hydræmic plethora does not lead to œdema so long as the heart and kidneys are in good order. As soon, however, as there is a failure in the circulatory system, it immediately leads to œdema; and the œdema of acute and chronic nephritis and cardiac disease is primarily due to the existence of hydræmic plethora. The great value of the milk cure in these conditions is now well established. But there is not a general agreement as to the cause of the improvement following the milk diet. It has been ascribed to the happy blending of the nutriments in the fluid, to the diuretic action of the lactose, to the absence of irritating substances, to the reduction of energy spent by the heart during the treatment, and to the effect the milk has in improving the tone of the cardiac muscle. Romberg and his followers, however, consider these effects are secondary, and the primary therapeutic effect of the milk is due to the almost complete absence of chloride of sodium. Milk contains but 1·6 grammes of sodium chloride per litre, and this small amount of salt is the reason for its value in cases of obesity without œdema or disturbance of the circulatory system, as well as in nephritic and cardiac diseases with œdema. Mendel argues that if the beneficial effect of a milk diet in these cases is really due to the poverty of milk in sodium chloride, the same effects would follow any other diet with a corresponding reduction in the amount of common salt. Clinical facts support his contention. For example: A patient who was suffering from myocarditis with dropsy was put on a milk diet; the quantity of urine increased, the ascites and anasarca disappeared. After a period of time the symptoms recurred, and, as the patient objected to the milk diet, the food now prescribed consisted of milk, meat, bread, butter, potatoes, and fruit, but with a minimum of salt. The œdema disappeared as rapidly as it had done with a milk diet. Other cases showed that the excessive consumption of salt was chiefly responsible for the appearance of dropsy. Mendel does not recommend that the prescription of salt-free diet should be absolute; but he considers the amount of salt should be limited to 2 to 4 grammes daily, and this is the quantity which is obtained on a milk diet without any added salt. During acute illness, such as pneumonia, fevers, and so forth, adults stand an exclusive milk diet very well; but there are many persons who cannot take it

[1] *Münch. Med. Woch.*, March 2 and 9, 1909.

except for a short time, and therefore another diet must be devised for them, and generally for persons who need a prolonged limitation of salt.

Ordinary bread contains from 1½ to 2 grammes or more of common salt per pound; it is therefore advisable that bread be made without salt; if it is considered unpleasant, it should be eaten with marmalade, jam, treacle, or honey. Butter usually contains 5 or 6 grammes of salt per pound, and should be prepared without salt for these patients. The greatest hardship is usually experienced in respect to meat. Fresh meat usually contains about 2 grammes of salt per pound, but the majority of people use a considerable quantity of salt as a condiment when eating it. This must be checked, even if it means a reduction in the amount of meat. Meat broths and extracts should also be limited for the same reason. But very frequently there are other reasons which necessitate a reduction in the consumption of butcher's meat, fish, game, poultry, soups, or broths. The protein, therefore, should be derived from sources which require the use of very little condiment; these are milk, milk puddings, eggs in the form of custard, creams, soufflé, omelettes made with sugar, eggs in egg-sauce or salad, poached eggs, and buttered eggs. Soups and meat jelly can be flavoured with mint, thyme, marjoram, parsley, celery, bayleaf, or savory. Cheese can be prepared with very little salt; cottage cheese, cream cheese, lactic acid cheese, Devonshire cream, may all be taken. There is no objection to puddings or pastry without salt, and they are not objectionable when eaten with cooked fruit. Various sauces can be used as condiments to the meat—*e.g.*, horseradish, vinegar, curry paste or powder, and vinegar sauce (vinegar, mustard, and sugar mixed together). One of the greatest difficulties is with regard to vegetables; potatoes, artichokes, carrots, parsnips, cabbage, cauliflower, and most other vegetables are considered unpalatable when no salt is used in the cooking, and therefore such vegetables must either be eaten without salt or only in very small amount until it is considered safe to increase the intake of sodium chloride.

The following is the diet recommended by Carducci[1] for dropsy due to renal disease: 2½ pints of milk, 300 grammes of meat (cooked and eaten without salt), and 300 grammes of salt-free bread, yielding 2,180 calories daily. This diet would contain about 3 grammes of sodium chloride, and it should be persevered with until the œdema is gone. Meanwhile the patient should remain in bed, and the excretion of sodium chloride watched by a frequent examination of the urine. The weight of the patient's body is a good guide to the effect of the diet: the weight usually sinks, the urine increases in amount, and the œdema diminishes. When the œdema is gone, the amount of sodium chloride can be increased by 3 grammes daily by giving come fresh-water fish, a little bacon or fat ham, or a trace of salt with eggs or vegetables such as potato

[1] *Brit. Med. Jour.*, 1906, ii., epitome 164.

or cauliflower. But Carducci strongly recommended that the urine should be regularly examined to insure that all the sodium chloride in the food is eliminated, and that the quantity consumed is only increased in proportion to the amount eliminated. This is a fair example of the salt-free diet, but it is impossible to keep the patient on it for a very long time. It should, however, be strictly carried out for two weeks, after which some vegetables should be allowed, to vary the monotony of the diet; these should be cooked with as little salt as possible, and washed in water without salt before they are eaten. Vegetables usually contain only 0·1 per cent. of sodium chloride, but spinach and celery contain more. Boiled cabbage or cauliflower can be eaten with a small amount of vinegar sprinkled upon them at the time they are eaten. Salads can be eaten with oil or vinegar and sugar, or egg-dressing when the patient is well enough to consume them.

There is no need for a salt-free diet in all cases of nephritis or cardiac disease, but only when they are accompanied by œdema. The tendency to dropsy can be determined by means of a test-diet, the essential thing being to find out first how much sodium chloride the urine of a healthy man would contain on such a diet, and compare the proportion eliminated by the patient with that of the healthy man. "If the excretion of sodium chloride is normal, there is no tendency to dropsy, and the consumption of salt should not be reduced unless the amount taken is obviously in excess of the needs of the organism, and even then it is not advisable to reduce the quantity to such an extent as to render the food unpalatable. In cases of heart disease it is usually sufficient to reduce the amount to a moderate quantity, and a very rigid salt-free diet is only needed in cases where there is a parenchymatous degeneration of the kidneys as a result of venous stasis."[1]

In obesity the effect of Karell's milk cure is believed by Romberg and Mendel to be due to the concurrent limitation of common salt in the diet. It is undoubtedly a fact that the reduction of sodium chloride in the food is a valuable means of reducing adiposity where there is œdema or disturbance of the vascular system; this is chiefly due to the increased diuresis, and the diminished retention of water in the tissues, leading to loss of weight. Karell's milk cure for obesity, however, is essentially a low-nutrition dietary, the amount of milk allowed being only sufficient to supply one-half or three-quarters of the energy expended by the organism daily. There is, however, great benefit to be derived by persons who are obese, or have a tendency to *embonpoint*, from the reduction of the sodium chloride in the food. Such persons should be recommended to eat as little salt as possible with their meat and vegetables, and fruit should form a portion of their diet because it contains only about 0·06 per cent., or less, of chloride of sodium, and needs no additional salt as a condiment.

In epilepsy the limitation of salt in the food is an assistance in

[1] Strauss, *loc. cit.*

carrying out a long course of bromide treatment. It is considered that chlorine-free food renders the organism more susceptible to the influence of bromine, that the sedative effect of bromide is thereby increased, while the risk of bromism is diminished. The following is the dietary recommended by Balint:[1] milk 1¾ to 2½ pints, butter 1¼ to 1½ ounces, 3 eggs, 9½ to 12½ ounces of bread daily, with vegetables and fruit, weak tea or coffee, and yielding 2,300 to 2,400 calories daily. The diet contains 2 to 3 grammes of sodium chloride; no salt is to be used in cooking or eating it. The bread may be salted by mixing 45 grains of sodium bromide with the flour of which each day's cake is made. Such bread is sometimes called Bromopan. The diet is useful in other nerve diseases where a course of bromide is considered desirable.

Cellulose Diet.—Cellulose is the material which composes the cell walls and woody fibre of plants. It is a nutrient for the lower animals. The herbivora are able to digest a considerable proportion of this material, varying from 60 to 70 per cent. of the crude fibre of dried grasses (hay) and cereals; 47 to 62 per cent. of that in carrots, cabbage, and celery; 25 per cent. of that in lettuce; but only 4·4 per cent. that in scorzonera. Hoffmeister found that the amount of hippuric acid in the urine of horses increased or decreased with the increase or decrease in the crude fibre digested. It is probable that primitive man had this faculty in common with other animals. It has been shown that the primitive races existing to-day—the Bushman, Nilotic negro, and others, possess a large cæcum, and their colon secretes an enzyme which dissolves the outer covering of vegetable cells; and the fluid from the vermiform appendix digests cellulose, evolving CH_4, and producing a copper-reducing substance. But the civilized races of mankind have lost this power. Bunge, however, considers that the epithelium of the colon always secretes an enzyme which has a slight action on the cellulose coverings of cells; nevertheless he agrees with the majority of observers that putrefaction is practically the only change which cellulose or crude fibre undergoes in the human intestines, and that the chief function served in the human economy by it is as a mechanical stimulus to peristalsis. But the importance of the existence of this stimulus in all animals possessing a long intestinal canal has been proved. If rabbits are fed on a diet containing no cellulose, the onward movement of the intestines ceases, inflammation ensues, and the animals rapidly die. The short intestine of carnivora does not require a mechanical stimulus to peristaltic action. The intestine of man is of a medium length, and a man's life is not endangered by deprivation of cellulose, although the movements of the intestine may thereby be impeded and a condition of sluggishness induced. If the muscular wall of the intestines has nothing to do, it is likely to atrophy, like any other muscle. The excessive fear of indigestible foods which prevails in the minds of many people is largely responsible for atonic constipation and many

[1] *Brit. Med. Jour.*, 1901, ii., epitome 50.

of the cases of chronic intestinal catarrh, mucous colitis, and membranous colitis. It is therefore important in the treatment of these diseases that the food does not lack cellulose and especially woody fibre. It is true that cellulose possesses irritating qualities which it is necessary to minimize in cases of chronic gastric and intestinal catarrh, intestinal ulcer, cancer, or stricture. It is also true that the presence of cellulose is a cause of food being hurried along the alimentary canal more rapidly than when this substance is absent, and in consequence some loss of nutriment arises. Thus, it was shown by Meyer[1] that more nutriment is absorbed from white bread than from brown or wholemeal bread; and Hoffmann showed that the addition of cellulose to a meat diet caused the food to be hurried rapidly along the canal and diminished the proportion of protein and fat absorbed from the meat. This irritating effect is desirable in cases of atony of the intestinal canal, and advantage should be taken of it. And the conclusion to be drawn from all observations is that the advantages arising from the presence of cellulose in the food of the average individual far outweigh the disadvantages.[2]

In cases of chronic constipation, and especially those complicated with mucous colitis, Von Noorden prescribes a diet of Graham bread (wholemeal bread), all sorts of legumes, including the skins, coarse oatmeal, all kinds of vegetables containing much cellulose or woody fibre, fruits having thick skins and seeds (grapes, currants, gooseberries), and large quantities of fat, such as butter, bacon, and ham. He claims that this diet permanently cures 50 per cent. of all cases, and another 28 per cent. are much improved or partially cured. The following diet list may be prescribed:

Wholemeal bread of any description, eaten with plenty of butter, bacon, fat ham, honey, treacle, or marmalade; one or two eggs daily, poached, buttered, or scrambled in preference; fat meat, bacon or ham for dinner, with a large proportion of dried peas, beans, lentils, cabbage, cauliflower, savoy, Brussels sprouts, turnips, swedes, parsnips, scorzonera, onions, leeks, and okra. Dessert should consist of raw or cooked fruit, especially apples, pears, grapes, currants, gooseberries, strawberries, raspberries, blackberries, loganberries, cranberries, and whortleberries. Plenty of cream should be taken with cooked fruit. Sugar is allowed. Peaches, plums, apricots, apples, and acid fruits in general also stimulate peristalsis by means of their organic acids. Oatmeal is of great value; the coarse meal is the best form, but oat-cakes and groats may also be eaten; pearl barley, barley bread, rye bread, and buckwheat cakes are useful. The foods which contain a comparatively small amount of cellulose or fibre should be avoided. The patient should take plenty of liquids; hot water should be

[1] *Zeit. f. Biol.*, 1871, vii. 132.

[2] Cellulose is a polysaccharide transformed by acids and alkalies into starch or dextrin. Many cellulose membranes have a coating of *lignin*, which is more indigestible, and it forms a variable portion of woody fibre.

drunk before breakfast, lunch, and dinner. Milk may be consumed to the amount of 1 pint daily, and will assist in bringing up the digestible protein to near the physiological requirement. China tea or cocoa may be taken to the amount of ¾ pint daily. A lacto-vegetarian diet is also valuable in many cases of chronic constipation.

Cellulose in Foods—Percentage.

Wheat	11·5	Lentils	3·0
Household flour	·7	Lettuce	·7
Patent roller flour	·2	Mushrooms	0·8-1·4
Entire wheatmeal	1·9	Okra or gombo	3·4
Bread: White	·5	Onions	·8
Wholemeal	1·2	Parsnips	2·5
French rolls	·4	Peas: Green	1·7
Barley: Meal or flour	6·5	Boiled	1·9
Decorticated	·3	Dried	4·5
Granulated	·7	Potatoes	·5-·8
Buckwheat: Whole	11·0	Sweet	1·3
Groats	·2	Pumpkin	1·1
Flour	·4	Radishes	1·7
Maize: Cornmeal	1·0	Rutabaga	1·2
Cerealine	·4	Salsify	·3-2·2
Hominy	1·0	Savoy	1·6
Millet	2·9	Seakale	·6-1·1
Oats	12·0	Spinach	·9
Meal	1·0	Squash (vegetable marrow)	·3-·9
Rolled	1·3	Tomatoes	·6-1·5
Rice: Polished	·3	Turnips	1·0-2·3
Unpolished	9·0	Watercress	·7
Rye: Meal	1·8	Apples (without pips)	1·2
Flour	·4	Bananas	1·0
Fine bread	·5	Blackberries	2·5
Black bread	1·3	Cherries	·2
Artichokes (Jerusalem)	·8	Currants	1·0-2·5
Asparagus	1·0	Cranberries	1·5
Beans: Dried	7·0	Grapes	3·6-4·1
String or kidney	1·9	Melon (musk-melon)	2·1
Boiled	1·7	Peaches (skins and stones)	3·6
Beetroot	1·0-3·0	Pears	2·7
Brussels sprouts:	1·5	Persimmons	1·8
Boiled	1·2	Pineapple (edible part)	·4
Cabbage:	1·8	Plums (skinned)	·6
Boiled	1·3	Pomegranate	2·7
Carrots	1·3-3·8	Raspberries	2·7-6·7
Boiled	1·1	Strawberries	2·4
Cauliflower	1·0	Whortleberries	3·2
Celery	1·0-1·8	Almonds	3·0
Cucumber	·7	Chestnuts: Fresh	1·8
Endives	·8	Dried	2·7
Horseradish	2·6	Hazel-nuts	3·3
Kohl-rabi	1·3	Peanuts	2·5
Leeks	1·1	Walnuts	1·7

Dry Diet.—In connection with the salt-free diet the theory of hydræmic plethora or hydræmia was mentioned, which condition Mendel considers is primarily due to the retention of sodium chloride in the tissues, and secondarily to the hygroscopic nature

of the salt. It was shown by Cohnheim and Lichtheim that if a large amount of physiological saline fluid is injected into the vessels of animals, no apparent changes take place; but the rate of circulation is increased until the extra amount of water has been excreted or the quantity of fluid in the vessels and tissues again becomes normal. If, however, the animal is killed before sufficient time has elapsed for this to take place, the organs of the abdomen are found to be œdematous. This evidence, as well as clinical facts, tends to show that hydræmic plethora of itself does not lead to the retention of fluid, but as soon as the circulatory organs become damaged, it immediately leads to œdema, anasarca and ascites.

The condition of hydræmic plethora occurs in many cases of cardiac and renal disease, and the damaged heart suffers from an excess of fluids in the body owing to the diminished action of the skin and kidneys. It is considered, therefore, that the consumption of the ordinary amount of fluids is injurious in these cases by distending the bloodvessels, increasing the blood-pressure, and overtaxing the heart. On the other hand, it has been urged that an insufficient consumption of fluids tends to reduce the blood-pressure too much, and thereby retards the excretion of the waste products of the body. In the treatment of cardiac diseases, especially senile heart, fatty heart, beer-drinker's heart, and other conditions in which there is a loss of muscular tone and vigour, resulting in abdominal plethora, ascites, anasarca, with tumidity of the liver or gastro-intestinal catarrh from passive congestion, Oertel, Von Noorden, Balfour, and others, aim at a reduction of the fluids in the bodily tissues by limiting the consumption of liquids to 15 ounces daily. At the same time they limit the consumption of carbohydrates on the ground that they supply material which readily undergoes fermentation, leading to the production of injurious fatty acids and gases which disturb the action of the heart, and slightly increase the proteins.

The diet may be exemplified as follows: Eggs, fish, fresh meat, poultry, tripe, and sweetbread form the basis of the food; dry toast, biscuits (crackers), and zwiebach are the chief sources of carbohydrate, which must be taken in small quantity; a tablespoonful of mashed potato or spinach is permitted, and a small amount of milk pudding, cooked apples, pears, prunes, plums, or an equivalent amount of ripe strawberries, raspberries, bananas, or tomatoes. The diet should be spare and the calorie value about 1,700 to 2,000 calories. The liquid should only amount to ¾ pint daily, consisting of a teacupful of tea, coffee, or cocoa, with sugar and cream, at breakfast and teatime, and a wineglassful of good wine at dinner-time, made up with water to 5 ounces, or 4 or 5 ounces of plain water with ½ ounce of good whisky or brandy in the evening. The meals should be four and a half or five hours apart, and the heaviest meal should be taken at midday; no food should be taken with the afternoon cup of tea, and the last meal should be eaten at about 7 p.m.

There is no doubt whatever about the advantage to be derived from a reduction of the consumption of liquids in many cases; but the strict limitation of liquids to ¾ pint daily is not beneficial in all cases, and, indeed, it may prove harmful by causing an accumulation in the tissues of the products of metabolism, irritating the kidneys by concentration of the urine; increasing resistance to the circulation by inducing a contraction of the small bloodvessels, whose lumen is probably already reduced in parts by arterio-fibrosis, whereby the already weakened heart is overtaxed.

The "dry diet cure," says Albu[1] is as old as the Greeks, but was revived by Schroth in his so-called *Semmelkur.* This consists of the consumption of five or six dry rolls in the course of a day, while liquids are entirely abstained from for a period of five or six days; after this time he allowed the patient to take some kind of porridge in the middle of the day, and a small amount of wine. Jürgenson found Schroth's diet useful in the treatment of pleural and peritoneal effusions, and likewise in hydrops articuli and old syphilitic joint troubles, but observed that abstinence from fluids caused great distress. Swieten found a dry diet useful in the treatment of dilated stomachs; it also meets the approval of Albu and Riegel for this disease, as well as for renal and cardiac dropsy.

Overfeeding Cures.—Overfeeding consists of the consumption of food having a higher protein and calorie value than that required for the physiological and dynamical necessities of the organism. In the case of adults, overfeeding is employed especially in the treatment of tuberculosis, certain forms of anæmia and chlorosis, neurasthenia, hysteria, visceroptosis, malnutrition generally, and convalescence from various diseases. Its employment is possible owing to the fact that the assimilation of excessive quantities of food may go on in spite of diminished functional (motor) power of the alimentary canal. The originators were Weir Mitchell and Playfair. In neurasthenic cases Weir Mitchell also insisted upon *isolation* of the patient; she should be removed entirely from her friends, and visited only by her doctor and nurse until a considerable improvement is made. The receipt or sending of letters, and other modes of communicating with the outside world are forbidden. She should be kept in bed for four to six weeks, fed abundantly, and massaged daily to overcome the evils of rest and high feeding.

During the first week of treatment the diet consists entirely of milk, which is given in doses of 2 to 10 ounces every two hours, day and night. The amount is gradually increased from 2 pints on the first day to 4 or 5 pints on the eighth. In the *second week* a further advance is made. About the ninth or tenth day a boiled egg, fried sole, or mutton chop, is given with some bread-and-butter, the amount of milk remaining the same. The next day a plateful of soup is given in place of one glassful of milk. And on the following day a chop or fish is accompanied by a spoonful of potato or vegetable. The amount of solid food is steadily increased, and by the

[1] *Deutsch. Med. Woch.*, 1907, I.

sixteenth day she should be able to take three full meals daily, including meat, fish, or egg and bacon for breakfast; and soup, fish, meat, or game, with potatoes, vegetables, and dessert, for dinner and supper, in addition to 4 pints of milk. The consumption of food by many neurasthenics has to be carefully watched; the nurse must be alert, for the patient who desires to avoid eating her food may resort to peculiar methods of disposing of it. A considerable amount of firmness combined with kindness must be used. The patient is only allowed to get out of bed to urinate or defæcate. Massage is usually begun about the fourth day of treatment, being performed at first for half an hour daily, but gradually increased to two or more hours, and continued up to the end of the treatment. The patient usually increases in size and weight, and when properly carried out, the cure is complete and permanent. Weir Mitchell says: "I have watched again and again, with growing surprise, some listless, feeble, white-blood creatures, learning by degrees to eat these large rations, and, under their use, gathering flesh, colour, and wholesomeness of mind and body."

It is not necessary to slavishly follow Weir Mitchell's plans. The object to be aimed at is the administration of a large amount of highly nutritious food in a relatively small volume; the intervals of feeding should be short, and the total amount of food consumed should have a heat value of 3,000 to 3,500, and, in special cases, 4,000 calories. Milk is not the only food necessary, and the mere bulk is too much for many people. A pint of milk of average quality yields 410 calories and contains 21 grammes of protein; so that 5 pints would contain 105 grammes of protein and 2,050 calories. The amount of protein should not be less than that, and the calories should be more. But it is practically impossible to give more milk. Casein and dried-milk powders can be used, also eggs, meat, fish, fowl, cream, butter, cream cheese, and other rich foods. The value of a milk diet consists of its blandness; it diminishes putrefaction in the alimentary canal, which increases its value when the case is complicated by diseases of the gastro-intestinal system, heart, or kidneys. Kephir and milk soured by cultures of the Bulgarian bacillus can be used, as they have the same nutritive value as milk, besides possessing properties calculated to diminish auto-intoxication, which many authorities consider to be the cause of neurasthenia.

If the case is complicated by gastric ulcer, overfeeding may at first be impossible; but functional diseases of the stomach are often benefited by a methodical increase in the amount of food consumed. The diet must be varied according to the secretory and motor powers of the stomach, and, for a good result to be obtained, Kuttner holds that it is necessary to estimate the tolerance of the organism for carbohydrates and fat respectively. The amount of protein should be modified by the age, habits, and calling of the patient. It should be gradually increased from the physiological minimum necessary to maintain equilibrium to a maximum. Naunyn puts the maximum quantity of proteins beneficial to diabetics at 120 grammes

daily. This may be adopted as a standard to aim at. It would be contained in 6 pints of milk.

Kuttner[1] holds that the *systematic* use of Weir Mitchell treatment in its customary form is not indicated for neurasthenics and many other cases for whom overfeeding is considered desirable; that for most cases muscular activity is urgently needed for protein digestion and for strengthening the heart-muscle. Albu found that with Weir Mitchell treatment the patient gains an average of 15 pounds during the first four weeks of treatment, and afterwards a slower gain, making a total increase of 25 to 30 pounds weight. The most important end of the cure, however, is not the formation of fatty tissue, but the replacing of lost tissue proteins, the strengthening of muscle, the rehabiliment of the nervous system, the recovery of tone, and improvement of the condition of the blood.

In sanatoria for consumptives it is possible to give an excessive quantity of food while the patient is not only allowed freedom of movement, but actually required to do some out-of-door work, such as gardening or other light occupation. The following diets by Dr. S. V. Pearson[2] are given as examples of the dietary in Mundesley Sanatorium:

THE SMALLEST DIET (PROTEIN, 129 GRAMMES; CALORIES, 2,650).

Food.	Breakfast.	Lunch.	Dinner.	Total.
Milk.. ..	500 c.c.	—	500 c.c.	1,000 c.c.
Bread ..	70 grammes	40 grammes	40 grammes	150 grammes
Butter ..	25 ,,	15 ,,	10 ,,	50 ,,
Meat ..	80 ,,	30 ,,	60 ,,	170 ,,
Fish.. ..	—	50 ,,	—	50 ,,
Pudding ..	—	100 ,,	125 ,,	225 ,,
Potatoes ..	—	80 ,,	80 ,,	160 ,,
Greens ..	—	40 ,,	40 ,,	80 ,,

THE LARGEST DIET (PROTEIN, 212 GRAMMES; CALORIES, 4,016).

Food.	Breakfast.	Lunch.	Dinner.	Total.
Milk.. ..	500 c.c.	500 c.c.	500 c.c.	1,500 c.c.
Bread ..	90 grammes	60 grammes	60 grammes	210 grammes
Butter ..	40 ,,	15 ,,	15 ,,	70 ,,
Meat ..	120 ,,	80 ,,	80 ,,	280 ,,
Fish.. ..	—	70 ,,	70 ,,	140 ,,
Pudding ..	—	150 ,,	150 ,,	300 ,,
Potatoes ..	—	90 ,,	90 ,,	180 ,,
Greens ..	—	50 ,,	50 ,,	100 ,,

The danger of carrying the treatment by overfeeding too far is a real one. The longer the overfeeding lasts, the smaller becomes the increase of tissue protein week by week, and the greater the addition of fat. In consumption the immoderate overfeeding may lead to serious cardiac debility, in addition to the minor evils arising from

1 *Med. Klin.*, May 9, 1909. 2 *Cf.* Starling, *Lancet*, 1906, ii. 851

the accumulation of fat, the lessened capacity for work, and diminished resistance. The condition of the excretory organs also require consideration as well as that of the circulatory system.

In cases of anæmia and chlorosis an overfeeding cure may be very beneficial, but only where the nutrition was previously bad and the cause of the faulty nutrition can be ascertained. If Weir Mitchell treatment cannot be obtained, or sufficient rest cannot be had, and overfeeding with ordinary mixed food does not cause an increase of weight, a good method is to increase the consumption of fat, while the protein is kept at about 100 grammes daily. Butter, cream cheese, fat ham, or bacon, are substances which can usually be taken in large amount with bread, potatoes, vegetables, and puddings. Milk diet is not suited for chlorosis. It is deficient in iron. But it may be taken to the extent of a pint a day. The best sources of protein are underdone meat, game, poultry, and raw-meat juice.

Underfeeding.—Neither men nor animals possess any sure instinct to guide them as to the quantity or quality of food they should eat. Civilization has placed at man's disposal very large quantities of food. The development of the art of cooking, concurrently with the improvement of our foodstuffs, has led to the preparation of the food in such a manner as to spare his digestive organs much of the work which devolved upon them in the precivilized state. The prevalence of excessive eating and the results which follow it are largely due to the art of cooking. Cooked food is more pleasant to the taste. By it the appetite is stimulated, and the habit of eating more than is necessary is readily acquired. Fonssagrives said: "Each meal may be divided into three parts—the first for necessity, the second for gluttony, and the third for disease to come." This dictum is an exaggeration when applied to the majority of people. But an immense number of people eat a good deal more food than is necessary, and the excess is a common cause of numerous ailments. Our forefathers submitted to periodical bleedings, which had the effect of relieving them from the consequences of superalimentation. Since the rejection of this mode of treatment, various others have come into vogue, such as the "cure" by aperient waters, baths, and lastly by a course of underfeeding. As a cure for obesity, underfeeding was first systematically employed by Brillat-Savarin, and later on by Banting, Karell, Oertel, Ebstein, Von Noorden, and a long line of physicians. All these authorities gave dietaries which yielded somewhat less than half the energy-producing value of the normal food, and nearly all of them considered that meat and other nitrogenous foods should form the basis of the dietary. It should, however, be stated at once that a too sudden reduction of the calorie value of the food may cause a loss of power or resistance to disease, or diffuse inflammation of the kidneys. It should be remembered that the energy expended in the performance of the physiological functions is never less than 1,400 calories, and with a person lying in bed the daily expenditure is usually about 1,6co calories. One has to consider

how far it is safe to drop the allowance below that which is required for the physiological work of the organism *apart from physical labour.* Banting's diet provides only about 1,150, Oertel's 1,200 to 1,600, Ebstein's 1,300, Von Noorden's 1,350, and Karell's milk 1,200 to 1,600 calories. It matters very little whether fat or carbohydrate be reduced the most, but both should be reduced. The consideration of protein is far more important. Banting's diet was practically all meat, and contained about 180 grammes of protein. Salisbury's meat diet contains about 220 grammes. These amounts are considered far too much by many authorities. The popular notion that a diet of lean meat " eats up the fat " which has accumulated in the body is due to the food usually being of low calorie value or deficient in carbon. Oertel reduced the amount of protein to 160 grammes, but he allowed 25 to 45 grammes of fat and 75 to 120 grammes of carbohydrate. Ebstein reduced the protein to 100 grammes, the carbohydrate to 50 grammes, and raised the fat from 60 to 100 grammes. Albu considers it is impossible to consume 100 grammes of fat with such a limited amount of carbohydrate, and that 100 grammes of protein is too little when the heat value of the food is below 1,500 calories, and recommends that the protein should be not less than 120 grammes daily. Von Noorden recommends protein 150, fat 30, carbohydrate 100 grammes; calories about 1,350. Kuttner[1] considers the suitability of various other cases for treatment by underfeeding. Some of these have already been mentioned under the head of Milk Cures. The whey cure is another system of underfeeding. Cases of myocarditis, with a basis of arterio-sclerosis, are often benefited by the limitation of food and drink, but heart disease accompanied by parenchymatous nephritis and a weak pulse is not suitable for treatment by underfeeding. " Of kidney diseases," Kuttner considers, " the condition of contracted kidney specially indicates treatment by underfeeding and limitation of fluids; but injury is often done by treating all cases of albuminuria on these lines, especially cases of orthostatic albuminuria in childhood." Neither should the food be reduced in cases of slight atony of the stomach and bowels, visceroptosis, and in general debility, where the gastric disturbances are only functional.

The **Tufnell** and **Bellingham diets** are combinations of the " dry diet " and underfeeding used in the treatment of aneurism. It was first prescribed in 1852 by Bellingham, and again in 1875 by Tufnell. Valsalva kept his patients in bed for forty-two days at a time, and bled them frequently. Tufnell kept them in bed for sixty to one hundred days without bleeding, but with a diet consisting of 10 ounces of solid food and 8 ounces of liquids daily, the object being to reduce the force and frequency of the heart, and thereby favour the deposition of fibrin in the sac of a sacculated aneurism. Bellingham and Tufnell permitted three meals a day, each consisting of 2 ounces of liquid and 2 ounces of solid food, with 3 ounces of cooked meat and a little potato in the middle of

1 *Klin. Med.*, May 9, 1909.

the day. It is not a very satisfactory method of treatment, and is falling into disuse. A diet of low energy value—say, 1,200 calories—consisting of bread, meat, potato, and butter, would do as well and cause less trouble and anxiety to the patient and attendants.

In all cases where a diet of extremely low value is adopted the object of the treatment should be fully explained to the patient, and he should have sufficient strength of will to put up with the discomfort for six weeks. That people can bear absolute starvation for four or six weeks has been shown over and over again, but patients who have any disease of the cardiac valves should not be submitted to treatment with food of such low value. Something can be done to diminish the distress of patients by letting them lie upon a water-bed, while the dryness of the mouth is checked by painting the tongue with glycerine, sponging it with borax-water, ice-water, or boracic lotion. The heart and aneurism must be watched. If the pulse becomes very frequent, the tongue very dry and brown, and the patient very restless, some modification should be made in the diet, and the first addition should consist of water or milk and water.

There are other systems of underfeeding, consisting for the most part of fads followed by numerous votaries.

The "low protein diet" of Chittenden has been referred to on several occasions, and especially when considering the amount of protein required by the body. Vegetarian and fruitarian dietaries have usually a low protein value. One of the most able exponents of the vegetarian system in England is Mr. Eustace Miles, whose success as an athlete is advanced as a proof that strength and endurance can be obtained from a vegetarian diet as readily as from the ordinary mixed diet. Miles, however, is not a strict vegetarian, but a lacto-vegetarian. Food consumed and recommended by him consists of milk, cream, butter, eggs, cheese, casein preparations, with cereals, legumes, vegetables, fruits, nuts, sugar, salt, and other condiments. He lays stress upon eating leisurely, condemns hurry under any circumstances, and lays down rules for daily physical exercises and for the cultivation of the mind as well as the body. He preaches "the gospel of fitness," but it seems almost impossible for any but the wealthy and leisured classes to follow his teachings thoroughly.

A change of diet in the direction urged by vegetarians would have great economical advantages, because vegetable proteins are less costly than those of animal origin. But one should always bear in mind the fact that there is a physiological minimum for the necessity of protein, that growing children need proportionately more than adults, and that it is probable that the majority of people are stronger and better in health when they consume a moderate amount of meat, game, fish, and other animal foods. *A moderate amount* is greater than the physiological minimum, and may be fixed at 1 gramme of protein per kilo of body-weight for

ordinary persons, more being allowed during the period of growth and during special occasions, such as pregnancy and lactation.

The No-Breakfast Plan and the Fasting Cure.—The Frenchman as a rule takes little food before midday, but contents himself with a cupful of chocolate and a roll. This allowance is very small for the first meal of the day, when compared with the egg-and-bacon, fish, or meat, consumed by the average Englishman at an early hour of the morning. But even the Englishman's breakfast is considered meagre in the United States and Canada, where the meal almost universally consists of meat, cereals, fruit, and other foods. It is possible that there are many people who would be better in health if they had no breakfast, but as a general rule it would be better for such people to eat somewhat less at each of the meals than to miss an important meal altogether. The no-breakfast plan is not an ideal institution, especially for the inhabitants of cold, northerly climates. The body must use some material for the production of heat and energy, and abstinence from food until the middle of the day tends to use up too completely the stores of protein and glycogen, as well as a little fat. There is a small percentage of persons who from habit and disposition eat no more breakfast than the roll and chocolate of the Frenchman; but if a number of such persons were canvassed, it would be found that, as a general rule, their health is poor in comparison with that of the breakfast-eater.

The apostle of the fasting cure was the late Dr. E. H. Dewey, of America,[1] who recommended fasting as a remedy for many diseases and conducted fasts of four to eight weeks' duration. There is no doubt whatever that short fasts of a few days to a week may be beneficial to many people. Such fasts have been practised from the remotest antiquity. A generation ago Keith, of Edinburgh, treated many of his patients by short fasts, allowing only hot water to drink. Such fasts, however, are very moderate compared with those prescribed by Dewey, who at first recommended the no-breakfast plan, on the supposition that people ate a good deal more than was good for them, and that their troubles could be relieved by abstinence. Later on, Hereward Carrington,[2] a disciple of Dewey's, published a "physiological study of the curative power of fasting," in which he attempts to assail the fundamental principle of dietetics, that the food of the body is the source of the heat and energy exhibited by it. We cannot occupy space in replying to the assertion that food is not a source of heat or energy. We can only agree that moderate fasts are beneficial, and that it is advisable that all such fasts should be carried out under medical supervision, and that in a large number of cases a modification of the diet, such as by only taking whey, buttermilk, or a pint or two of milk daily, will give as much benefit as absolute fasting.

Fletcherism.—If the no-breakfast plan or the fasting cure are

1 "The No-breakfast Plan and Fasting Cure," 1900.
2 "Vitality, Fasting, and Nutrition," 1908.

admitted to be beneficial to some people, the same may be said of the method of treatment recommended by Mr. Horace Fletcher. Dewey's crusade was against overfeeding; Fletcher protests against insufficient mastication. Both men have a scientific basis for their methods, both have carried their principles to an irrational extreme. Fletcher, however, does not go to the same extreme as Carrington. His system is to chew each mouthful of food until it is reduced to a fluid, to swallow only the liquid, and to remove the solid residue from the mouth with the fingers. The system is not exactly new. Something of the kind was taught in ancient times by Epimenides of Crete. Fletcher claims that when his system is adopted, a relatively small amount of food appeases the appetite, in consequence of which there is a loss of body-weight, but *the general health and activity are improved*, and all digestive troubles cease. Fletcher, while an athlete of considerable eminence at Yale University, maintained his body in perfect health and fitness on a diet containing only 60 grammes of protein and 1,600 calories. These figures are low, but it has been shown again and again that the nitrogenous equilibrium can be maintained upon this amount of protein. Chittenden personally investigated his metabolism, as well as that of other athletes, and proved that they could maintain mental and physical vigour upon a daily output of nitrogen representing the metabolism of 55 grammes of protein, or about half the amount usually recommended in standard dietaries. There is no doubt, as stated elsewhere, that the consumption of animal foods usually exceeds the actual requirement. The investigation has done much towards breaking down the standards, but Fletcherism cannot be accepted in its entirety. It is admitted that mastication is sadly neglected by a vast number of people, that food is bolted, and additional work thrown upon the digestive organs to digest and assimilate it; but surely it is not only unnecessary, but inadvisable, to remove the residue of the masticated food from the mouth. Fletcher argues that it prevents a large amount of waste material reaching the intestines, where it exercises an injurious effect. It has, however, never been shown that the presence of food in the intestines is injurious, or that there is any advantage in the presence of a small amount of fæces. In the majority of cases the reverse obtains. With regard to the small calorie value of Fletcher's mode of feeding, it must be asserted that 1,600 calories does not represent the amount of energy expended by the body while doing ordinary work, and that the average individual expends from 2,000 to 3,000 calories or more according to the amount and kind of work done. As a system of underfeeding, Fletcherism is of undoubted value for many cases previously detailed. The inculcation of careful and prolonged mastication by dyspeptics and many other persons is a point which the physician has ever to bear in mind; but it would be a delusion to imagine that mastication, however carefully it may be performed, can increase the value of the proteins, fats, or carbohydrates, which comprise the nutriment in the food consumed.

CHAPTER VIII

STIMULANTS

INASMUCH as stimulants form an important part of the beverages used by mankind, some account of their value and effects on metabolism is requisite. The chemical side of these substances has been fully dealt with in the companion volume on "Foods: their Origin, Manufacture, and Composition."[1] The reader is referred to it for further information.

Alcohol in Health and Disease.

Every alcoholic beverage is a combination of alcohols, ethers, acids, aldehydes, sugars, and salts. The chief of these is ethyl alcohol (C_2H_6O). It arises from the hydrolytic cleavage of sugar in fermentation, 100 parts of sugar being transformed into 105·26 parts of dextrose, which yields alcohol, 51·11 parts; carbon dioxide, 49·31 parts; succinic acid, 0·67 part; glycerine, 3·17 parts; and materials combined with the ferment, 1·00 part. The amount of ethyl alcohol in different beverages is as follows:

ALCOHOL IN BEVERAGES (PER CENT. BY VOLUME).

Liqueurs	33 to 60	Australian wines	10 to 15
Rum	50 to 70	Californian wines	10 to 15
Whisky	43 to 50	Champagne	11 to 15
Brandy	43 to 65	Home-made wines	9 to 16
Gin	38 to 50	Cider and perry	5 to 10
Port and sherry	17 to 25	Pale ale	6 to 7
Madeira and Malaga	15 to 25	Beer	4 to 7
Claret and Burgundy	10 to 15	Porter and stout	6 to 7
Hock and moselle	10 to 15	Lager beer	3 to 5
Hungarian wines	10 to 12	Herb beer	2 to 3
Italian wines	9 to 15	Kephir and koumiss	1 to 3

Fusel Oil.—Besides ethyl alcohol, any other of the primary alcohols may be present. Wine and spirits contain propyl, butyl, amyl, hexyl, and heptyl, alcohols; besides small quantities of secondary alcohols. All these bodies are usually classed together as higher alcohols, or "fusel oil." According to Ehrlich,[2] they arise from the destruction of proteins; but they arise in spirits

[1] Baillière, Tindall and Cox, 1912.
[2] *Ber. d. Deutsch. Chim. Ges.*, 1906, xxxix. 4072.

after distillation, and as they contain no protein, another origin must be sought.

Acids.—Fermented liquors contain many acids. In malt liquors there are lactic, malic, acetic, valeric, tannic, and gallic acids. In wines the free acids are acetic, citric, tartaric, malic, malonic, saccharic, caproic, suberic, and others; and the combined acids are tartrates, acetates, citrates, racemates, butyrates, propionates, etc.

Ethers.—These are formed by the interaction of alcohols and acids, and contribute to the flavour of the beverage. The bouquet of wines, called *œnanthyl ether*, is a combination of acetic, œnanthic, capric, and caprylic ethers. Rum contains ethers resulting from the action of acetic, saccharic, and suberic acids upon alcohol, the chief result being ethyl suberate. Brandy contains acetic, œnanthic, propionic, butyric, and caproic ethers. Beer contains traces of amylic, acetic, valeric, and caproic ethers.

The Heat Value of Alcohol.—The heat resulting from the combustion of alcohol is 7·067 calories per gramme. It is isodynamically equivalent to 1·7 grammes of carbohydrate. But as a source of heat to the body it is inferior to the sugar from which it is derived; 100 grammes of sugar yield 410 calories, but only yield 51 grammes of alcohol, having an energy value of 360 calories.

The Food Value of Alcohol.—It was formerly considered that no alcohol was used in the body, and that the nutritive properties of wine or beer were derived from sugar, proteins, and extractives. It is now known that some alcohol is actually utilized, and that it yields heat in the same way as other foods. This is proved by the fact that when moderate quantities of alcohol are consumed, only 1·5 or 2·0 per cent. is eliminated unchanged by the skin, lungs, and kidneys.

The amount of alcohol which the body can oxidize is limited.

Parkes and Wollowicz[1] considered not more than 2 ounces (57 c.c.) per diem was completely oxidized. With this quantity only 1 to 3 per cent. escaped unchanged; with a larger dose 10 per cent. escaped combustion, some portion being eliminated as acetaldehyde, acetic ether, and acetic acid, and some alcohol remained in the tissues. Atwater and Benedict[2] found that when 72·5 grammes of alcohol (equivalent to 5½ ounces of whisky) was consumed, only 2·9 per cent. escaped unchanged, and there was little evidence of the excretion of partially oxidized products. The amount which any person can oxidize appears to be a matter of idiosyncrasy and habit. It is not uncommon for topers to consume a bottle of spirits (35 ounces) a day; and there is no record of the amount of unoxidized alcohol or its by-products eliminated by such persons. The constant presence of partially oxidized alcohol in the expired air of such persons is discovered by the odour of their breath. But it does not follow that the oxidized alcohol is a source of energy. To prove that it is a food, Bunge[3] says: "We do not know whether

[1] Proc. Roy. Soc., xiii., xix., xxx.
[2] Atwater and Benedict, Bulletin 69, p. 28, U.S. Department of Agriculture.
[3] "Physiol. and Pathol. Chem," p. 117.

alcohol is a source of energy; and it is necessary to show that the energy liberated by the oxidation of alcohol is used in the performance of normal function. It is not enough to show that potential energy is transformed into kinetic energy. The transformation must occur at the right time and in the right place." It may be asserted that the heat derived from the combustion of alcohol must economize the use of other foods. This is questionable. The paralyzing effect of alcohol on the vasomotor system causes dilatation of the cutaneous vessels and increased loss of heat, the result being a reduction of the temperature of the body. The idea that alcohol warms the body in cold weather is due in the first place to flushing the skin with blood, and in the second to the narcotic effect on the central nervous system. It lowers the temperature of the body. In Ross's Antarctic expedition spirits were found deleterious to the men; they were colder and more fatigued after a dose than before it, and the drinkers were more liable to scurvy than the abstainers. The Hudson Bay Company also found alcohol lessens the power of the men to bear cold, and have excluded it from their provisions. There are plenty of cases recorded of people living for weeks together on alcoholic beverages and nothing else. Publicans have instanced persons who drank 20 pints of beer a day. This quantity, assuming it to be of average quality, would contain 568 grammes (more than 18 ounces) of alcohol, 600 grammes of carbohydrate, 33 grammes of protein, and on combustion would yield 6,800 calories. This supply of energy is enormous, and if utilized, would be enough for two men doing a moderate day's work. But a diet consisting wholly of beer would be deficient in protein. Binz found that alcohol reduces the excretion of nitrogen, and is a protein sparer. Scientific opinion is not unanimous on this point. Parkes and others, who made careful observations, failed to notice any reduction in nitrogen excretion. Miura[1] fed himself on carbohydrates and fat until the nitrogen excretion was at an equilibrium. He then replaced part of the carbohydrate with an isodynamic quantity of alcohol, and his nitrogen excretion was increased. Hence he concluded alcohol did not spare the tissues. In larger doses it increased the output of nitrogen. In this respect it resembles arsenic and phosphorus, which cause a breakdown of the protein-molecule, the nitrogenous portion being excreted, and the fatty moiety oxidized or stored as fat.[2] This explains the accumulation of fat in those who drink much beer. Hutchison says alcohol paralyzes the cells so that they are unable to break down fatty compounds. It is a fat-sparer; to a less extent it spares carbohydrate; but it is doubtful if it interferes with the power of dealing with protein. He says alcohol "is consumed and yields energy, and therefore is entitled to rank as a food. . . . It does not follow it is as good a source of heat as fat, quite the contrary; it causes more heat to be lost than it pro-

[1] *Zeit. f. Klin. Med.*, 1892, xx. 137.

[2] Busage, "Physiol. and Pathol. Chem.," p. 121.

duces. Still less reason is there to suppose it is a useful muscle food." [1]

Alcohol does not give Strength.—The idea that alcohol increases the power of endurance, gives greater energy and ability to work longer, pervades the public mind. The experience of many who take a glass or two of beer daily is that they can continue to work longer than when they do not take it. Scientific observations do not support this opinion. Alcohol is a poison to protoplasm and depresses cellular activity. All solutions of alcohol affect unicellular organisms in proportion to the quantity: 1 to 5 per cent. paralyzes them; 6 per cent. produces immediate arrest of all motion. Growth is checked in torula, eggs of earthworms, ascarides, tapeworms, leeches; hydra, leeches, earthworms, snails, tadpoles, crayfish, and other fishes are killed by it. Muscular contraction is weakened in proportion to the amount of alcohol. This can be proved in the frog and other small animals by direct experiments. Experiments on men show that the muscular work performed under its influence is less than without it. Accurate measurements have been made. Rivers [2] found by the ergograph that 5 to 20 c.c. of alcohol had no effect on the quantity or quality of work done; with 40 c.c. the evidence was uncertain; but 80 c.c. caused a decided falling off in the amount of work done. Alcohol deadens the sense of fatigue by paralyzing the nerve centres, it allays discomfort, produces a feeling of light-heartedness, and enables the workman to endure a greater strain or work longer than without it. But muscular work is not better done under its influence, nor is the endurance increased beyond a short period. Scheffer found alcohol first increases and then diminishes muscular power. If the peripheral motor nerve apparatus is first eliminated by curare, the alcohol has no stimulating effect.

The experience of military commanders and other governors of large bodies of men of every description, in all climates, and in every viscissitude of temperature, shows that men are better able to perform arduous duties, endure prolonged exertion and exhausting marches, when no alcohol is allowed as part of their daily food. They can bear hunger and fatigue, heat and cold, snow or rain, better without it. General Grenfell says: "The Egyptian campaign was a teetotal campaign. I took over the rear-guard at the finish, and I have never seen a force of men so fit and so well as that force." Kitchener allowed his men no alcohol in the Soudan campaign, and encouraged them to drink cold tea when on long marches. In the South African War the Boer leaders prohibited the use of alcohol, but the British soldiers were not abstainers. Sir F. Treves, who was with the Ladysmith column says: "The first men who dropped out of that army of 30,000 were not the tall men, or the short men, or the big men; they were the drinkers, and they dropped out as clearly as if they had been labelled with a big

[1] "Food and Dietetics," p. 328.
[2] "Croonian Lectures," 1906, and *Brit. Med. Jour.*, 1908, i. 1192.

letter on their backs." Industrial leaders give the same experience. In one year at Uxbridge 23,000,000 bricks were made. The average number made by beer-drinkers was 760,269, and by teetotallers 795,400, or 35,131 in favour of the latter. The highest number made by a beer-drinker was 880,000, and by a teetotaller 890,000, leaving 10,000 in favour of the teetotaller. The lowest number made by a beer-drinker was 659,000, and by a teetotaller 746,000, or 87,000 in favour of the teetotaller. At another place the printers were compared, and it was found that the number of letters composed per diem was less when alcohol was taken, the average diminution being 15·2 per cent. Its effect on mental work has been referred to in a previous section, where it was shown that memory, attention, and the association of ideas were adversely affected by alcohol. But this is largely a matter of idiosyncrasy, some people being affected more than others. There is evidence to show that the best mental work is performed without it. There is usually a stage when the cerebral activity is slightly increased and its faculties sharpened; but this is followed by a period of constantly diminishing power, when thought is slower and a longer time is required to perform a known quantity of mental work, and the results are less certain.

Effects of Alcohol on Digestion.—Alcohol is primarily an appetizer. It sharpens the palate, increases the desire for, and enjoyment of, food, and to that extent is beneficial. Convalescent, debilitated, and aged persons frequently eat more food when it is accompanied by a glass of beer, wine, or diluted spirits. The value of such a beverage to those who need stimulation, and especially to those whose occupation is sedentary, is admitted by most scientific men. But when they investigate the influence of alcohol on digestion, their results are not in favour of it. Digestion is not better performed when alcohol is present, nor does appetite return so soon. Kretschy[1] made observations on a person having a gastric fistula; Buchner[2] on a healthy person by the aid of a stomach-pump. Both found digestion hindered by the presence of alcohol. Blumeneau,[3] following the example of Buchner, found that during the first three hours alcohol hinders digestion by causing lactic acid to be secreted in place of hydrochloric acid; a large quantity of alcohol hindered more than a small one; the motor activity and absorptive power of the stomach were hindered in proportion to the quantity of alcohol; but the secretion of gastric juice was prolonged; during the fifth and sixth hours after the meal hydrochloric acid is rapidly secreted, and digestion quickly completed.

Experiments in artificial digestion are numerous. But it must be borne in mind that the conditions are different. The proportion of pepsin and hydrochloric acid can be regulated by prior preparation. Both acid and ferment are there from the moment

1 *Deutsch. f. Klin. Med.*, 1876, xviii. 527.
2 *Ibid.*, 1881, xxix. 537.
3 *Brit. Med. Jour.*, 1890, ii., epitome 117.

the food is put in the mixture. Bearing these points in mind, the results obtained by Chittenden and Mendel[1] are interesting. It was found absolute alcohol in the proportion of 1 to 3 per cent. *stimulated* digestion by a fraction of 1 per cent., 2 to 3 per cent. *checked* digestion, and 3 per cent. *reduced* digestion 17·6 per cent. Pure rye whisky diluted to contain the same proportion of alcohol gave the same results, excepting when the whisky mixture contained from 1 to 3 per cent., in which case digestion was increased from 3 to 5 per cent. Brandy, rum, and gin gave corresponding results. As the result of these observations, Chittenden and Mendel expressed the opinion that "whisky only impedes the solvent action of gastric juice when it is consumed in immoderate and intoxicating quantities." Of course, this remark applies to gastric juice containing the normal proportion of pepsin and hydrochloric acid, such as would be made *in vitro*. But in the human stomach lactic acid replaces hydrochloric acid under the influence of alcohol, and the digestive power of pepsin in the presence of lactic acid is comparatively small. Sir William Roberts made numerous experiments in artificial digestion, the mixture consisting of 2 grammes of dried beef digested in 0·15 c.c. of hydrochloric acid, 1 c.c. glycerine extract of pepsin, a varying quantity of alcohol, and water to make 100 c.c. The results obtained were as follows:[2] The mixture without alcohol was entirely digested in one hundred minutes. When spirits were added, 5 per cent. of proof spirit—whisky, brandy, or gin—did not affect the time required for digestion; 10 per cent. prolonged the time to 115, 20 per cent. to 135, 30 per cent. to 180 minutes, and when 40 per cent. was added, the digestion was embarrassed and peptonization scarcely occurred. Port wine had the same effect up to 10 per cent.; but above this proportion it had a slightly greater inhibitory effect than spirits; 20 per cent. prolonged the digestion to 180 minutes, 30 per cent. to 200 minutes, and with 40 per cent. there was scarcely any peptonization. Sherry had a greater inhibitory power than port: the presence of 20 per cent. of sherry—*i.e.*, about 4 per cent. of alcohol—trebled the time required for digestion, and 30 per cent. of sherry almost entirely inhibited digestion. These figures are important, as ½ pint of wine is commonly consumed; but this amount in a total gastric charge of 2 pounds would amount to 25 per cent., and would seriously embarrass digestion until the wine is absorbed. It is remarkable that both wines have a greater inhibitory effect than any spirit, which Roberts says indicates "there must be in these wines some retarding agent besides alcohol." Malt liquors contain 4 to 6 per cent. of alcohol, but the inhibition of digestion due to such liquids is out of all proportion to the alcohol contained. Thus Roberts found 10 per cent. of Burton ale prolonged the digestion of the above mixture to 115, 20 per cent. to 140, and 40 per cent. to 200, minutes; 40 per cent. of lager beer or table beer prolonged the time to 140, and

[1] *Modern Medicine*, September, 1896.
[2] "Digestion and Diet," pp. 134-141.

60 per cent. to 180, minutes. These beverages are frequently consumed with meals, and form 50, 60, or even 80, per cent. of the contents of the stomach during digestion.

The effects of alcohol on starch digestion vary according to the form in which it is consumed. It stimulates the nerves of the mouth and causes a profuse secretion of saliva. To this extent it promotes digestion. But artificial digestion experiments show that it checks the action of ptyalin, and thereby retards the digestion of starch. This effect is not very marked when ordinary doses of spirits are consumed; even 40 per cent. did not entirely stop it. But Roberts found "50, 60, or 80, per cent. of malt liquor in the digesting stomach, common proportions, acted as a powerful retardant, especially on the digestion of bread and other farinaceous foods."

As regards its influence on the motor power of the stomach, the investigations are in favour of the moderate use of alcohol. Binz found the muscular activity stimulated to a certain extent by alcohol, and others have found the same. But this conclusion is not accepted by all men. There are some who assert that the primary increase of motor activity is due to a local irritant effect, and is followed by a secondary decrease of motor activity due to nervous depression, as the result of which the gastric movements are slow and languid. Binz found olive-oil discharged from the stomach more rapidly when alcohol was used than when it was not used. But test meals, with and without alcohol, show that there is a delay in the passage of food from the stomach after taking alcohol. Penzoldt and Wolffhardt found 30 to 40 grammes (1 to $1\frac{1}{3}$ ounces) of brandy taken before or during a meal shortened the time of gastric digestion by half an hour; and red wines had a proportionate effect; but this is contrary to the experience of other men. Hutchison[1] considers the moderate use of alcohol in health and disease is beneficial through its influence on digestion. He says alcohol promotes the secretion of gastric juice by directly irritating the gastric mucous membrane; and after its absorption, it brings about a more profuse and sustained flow of gastric juice. Zuntz[2] considers beer, when consumed to the extent of 60 grammes of alcohol daily, had no deleterious effect on digestion. Mogilianski showed that the assimilation of fat decreases under the influence of small doses, but increases when moderately large doses of alcohol are consumed.

The Habitual Use of Alcohol.—There are many persons who, during all their lives, consume what they call a moderate quantity of alcohol daily, and to all appearance are none the worse for it, declare themselves to be better for it, are healthy, and die at a good old age. Such cases are often quoted to prove the harmlessness of the regular use of alcohol. But for one person who keeps well and lives to advanced age, hundreds succumb early to diseases acknowledged to be caused or aggravated by alcohol. There is likewise a class of people, by no means small, to whom even a small

1 "Food and Dietetics," p. 324. 2 *Archiv. Physiol.*, xliv. 444-451.

dose of alcohol is an undoubted poison; and a still larger class to whom the daily use of a moderate dose of alcohol is a direct or indirect cause of ailments which render life miserable and shorten its duration. The demands of city life on the nervous system is given as a satisfactory reason for the regular use of alcohol by many people. But the benefits derived from alcohol by persons in health could be obtained from other foodstuffs. Very few people would be any worse if they did not take it, and very many would be better if they abstained from it. *It should be looked upon as a luxury!* But medical opinion is divided. In one division there is Sir Victor Horsley,[1] who says: "The contention that small doses of alcohol, such as people take with their meals, had practically no deleterious effect, could not be maintained. It renders the consumer more liable to microbic invasion. . . . Its effect on the brain is marked. There is first a quickening of cerebral action, lasting only a few minutes, followed by a marked diminution of cerebral activity lasting from two to four hours. . . . The disadvantageous effect on the performance of muscular work is well known; indeed, the best physical results are obtained without alcohol." Bunge[2] says: "There is a strong belief that alcohol gives new strength and energy after fatigue sets in. This is erroneous. The idea originates from a paralytic deadening of the sense of fatigue. . . . Alcohol makes no one stronger. . . . Even if we grant alcohol is a source of energy, it is far smaller than that contained in the carbohydrate from which it is derived." Another leader says: "Although primarily an appetizer, alcohol destroys appetite and hinders digestion. Its stimulating effect is only momentary, and after this passes off, the capacity for work falls continuously. It calls up the reserve energies of the body. It does not conserve energy, but dissipates it. It does not keep out the cold, but lowers the temperature of the body. As an energy producer, it is extravagant and may lead to bankruptcy."

The other division contains equally distinguished leaders. A manifesto signed by Crichton-Browne, Dyce-Duckworth, Jonathan Huchinson, Robert Hutchison, Fraser, Gowers, Halliburton, and McCall Anderson, was published in the *Lancet*, March 30, 1907. It states that: "As an article of diet we hold the universal belief of civilized mankind, that the moderate use of alcoholic beverages by adults is usually beneficial, is amply justified. We deplore the evils arising from the abuse of alcohol, but it is obvious that there is nothing, however beneficial, which does not by excess become injurious."

Definition of a Moderate Quantity of Alcohol.—This question is difficult to answer because the personal equation figures largely in the problem. We cannot do better than take the figures previously quoted from Parkes, Wollowicz, Atwater, and Rosa. According to the former, the body is capable of completely oxidizing a liquid

[1] "Alcohol and the Human Body," London, 1909.
[2] "Physiol. and Pathol. Chem.," pp. 117-121.

equivalent to $1\frac{1}{2}$ or 2 ounces of absolute alcohol. The maximum would be contained in 4 to 6 ounces of whisky or brandy, 10 to 20 ounces of wine, or $1\frac{1}{4}$ to 2 pints of beer, according as a high or low quality is consumed. There are many people who can dispose of more, and some who cannot oxidize even these amounts, thereby illustrating the adage, "One man's food is another man's poison." Respecting the time of day when alcohol should be taken, the best advice to give is, "Never take it except with meals, and never before the midday meal;" for many people it is prudent to take it only with the last meal of the day.

The Effects of Excessive Consumption.—Alcohol yields 7·1 calories of energy per gramme, but it is unknown to what extent the muscles use it. It causes a greater loss of heat by radiation from the body than it yields. It does not give strength, but diminishes muscular power while deadening the sense of fatigue. It is like a whip to a tired horse. In small doses it spares nitrogen by diminishing the output; large doses increase the output. In large doses it spares the consumption of carbohydrate and fat. It diminishes cerebral power. The continued use of alcohol causes loss of appetite, and may produce anorexia, nausea, vomiting; a slight excess tends to lessen the tone of the stomach, leads to atony, chronic catarrh, and possibly dilatation of the stomach. The portal vessels become engorged, leading to hyperæmia of the liver, which in turn causes catarrh of the stomach and bowels. The cells of the liver may undergo fatty infiltration or degeneration. When the excess is long continued, it irritates the fibrous elements of the liver, leading to hyperplasia, and ultimately cirrhosis. The effect of alcohol on the kidneys is similar to that on the liver, granular kidney being common.

As regards the heart, the increased frequency of the pulse after alcohol is commonly cited as an instance of its stimulating effect. But this is due to its action on the nerves and not on the muscle. Crile says shock is aggravated by alcohol. The excessive use of alcohol deteriorates the cardiac muscle, as it does other cellular organs. It leads to a permanent enfeeblement of contractile power, dilatation of the ventricles, flagging of the circulation, venous congestion of the abdominal organs, engorgement of the portal circulation, gastro-intestinal catarrh, and gradual failure of general nutrition.

The primary dilatation of the bloodvessels resulting from a dose of alcohol tends to become permanent when it is taken regularly or in excess. The small vessels of the skin, liver, stomach, and bowels are constantly dilated. Alcohol also causes an increase of the fibrous-tissue elements (*arterio-sclerosis*), accompanied by fatty degeneration or calcification. The increased fibrosis of the vessels throws an increased strain on the heart, and the tendency to blood-stasis and failure of nutrition is again observed. The degenerative processes in the vessels lead to serious changes in the cerebral structures, to say nothing of hæmorrhages from ruptured vessels leading to apoplexy or mental decay.

On the nervous system, chronic alcoholism produces marked changes. Horsley says it produces degeneration and ultimate destruction of nerves and their processes, and there is a gradual increase of neuroglia or supporting tissue. Its effect on the peripheral nerves is best seen in the cases of alcoholic neuritis occurring chiefly in women. It has also been shown that epilepsy is frequently due to alcoholism in the individual or his parents. Hysteria also arises, in many cases, from the nervous instability due to alcoholism in the individual or parents. Alcoholic insanity is on the increase. In the report for 1903 of the Morningside Asylum, Dr. Clouston said: "This year no less than 42·3 per cent. of the male and 18 per cent. of the female patients had excess of alcohol assigned as the cause of their insanity. . . . For every man in whom excessive drinking causes insanity, there are twenty in whom it injures the brain, blunts the moral sense, and lessens the capacity for work."

The effects of alcohol vary. No single case shows all the effects detailed. Some symptoms occur in one case, others in another. This is probably due to the form of alcohol. It is usually stated that the injurious effects of alcohol increase with the atomic weight, each alcohol in the scale being more injurious than the one below it. It follows that propyl, butyl, amyl, heptyl, and hexyl alcohols are more injurious than ethyl alcohol; the aldehydes and secondary alcohols are worse than the primary alcohols. All these are grouped together as **fusel-oil.** Furfural, or furfurane aldehyde, occurs in many wines and spirits, and arises from pentoses in the grain. It is very poisonous, causes epileptiform convulsions, and is probably responsible for alcoholic epilepsy. It is commonly present in grain spirit, immature whisky, absinthe, vermouth, other liqueurs, and to a small extent in beer. Amyl alcohol is from three to fifteen times as intoxicating as ethyl alcohol. It is a powerful poison: 2 drops are fatal to a guinea-pig; 60 drops caused a dog to be giddy, have muscular tremors, followed by paralysis of the hind-legs, foaming at the mouth, and coma lasting five hours. According to Ordonneau, 100 litres of brandy contain 83·8 grammes of amyl alcohol, 218 of butyl, 40 of propyl, 0·6 hexyl, and 1·6 heptyl alcohols. The same amount of whisky contains 24 grammes of amyl, 63 of butyl, and 11·7 of propyl alcohols.

Effect of Alcohol on Duration of Life.—Statistics show that the mortality among intemperate people is four or five times greater than that of strictly temperate people. This fact has been recognized by life insurance companies. They offer an advantage to teetotallers, and charge inebriates a higher rate of premium.

Alcohol in Sickness.—"Alcohol is a rapid and trustworthy restorative. In many cases it is truly life-preserving, owing to its power to sustain cardiac and nervous energy."[1] It is employed in many diseases. It was formerly much used in enteric fever, pneumonia, and all asthenic conditions, as much as 10 to 20 ounces of brandy in twenty-four hours being prescribed. Examples are

[1] "Manifesto on Alcohol," *Lancet*, March 30, 1907.

given by Anstie[1] of patients kept alive by brandy, without food, who did not waste so much as if they had been living on their own tissues. One ounce of brandy containing 35 per cent. of alcohol by weight yields 64 calories, good brandy having 45 per cent. yields 89 calories, and superior brandy (50 per cent.) yields 100 calories. Therefore 16 ounces of superior brandy would be required to supply the energy expended during absolute rest in bed by a person taking no food, supposing no more than 2 or 3 per cent. of alcohol escaped oxidation. But the experience gained in temperance hospitals proved that alcohol is not essential in asthenic diseases, that patients did as well without it, and in some cases it was injurious. Its place as a cardiac and nervous stimulant is taken by strychnia, ammonia, musk, and other drugs. But the use of alcohol should not be entirely discarded. If the consumption is limited to 2 ounces of alcohol, 5½ ounces of brandy or whisky, it may help a patient through the crisis of pneumonia or enteric fever by stimulating the flagging circulation, soothing the nervous system, producing sleep, enlivening the mind, and encouraging the patient.

There is considerable difference of opinion about the action of alcohol on the heart. Loeb, Rachem, and Dixon assert that small doses increase its contractile power. Munro and Findlay say it has never been proved that the heart muscle is stimulated by it. Martin and Stevens showed that blood containing a ¼ of 1 per cent. diminished the contractile power. With regard to blood-pressure, Stockmann found moderate doses of alcohol do not influence blood-pressure; large doses cause a fall of pressure. Charteris and Cathcart found *pure malt pot-still whisky* first causes the pulse-rate to rise and then sink to its former rate. The blood-pressure is slightly reduced. *Patent still whisky* causes the pulse-rate to rise 10 per minute, then to fall slightly below normal. The pressure varies with the pulse. *Absolute alcohol* caused a slight reduction of pressure. Clinical experiments in pneumonia showed no reduction in pressure after taking alcohol when the heart was embarrassed. Therefore there is no better rule that the old dictum: "So long as alcohol reduces the pulse-rate, steadies the heart, and increases its tone, it is doing good." But alcohol is not a food for the heart; it enables it to draw on its reserved strength. The period of over-activity may be followed by depression, in which the cardiac beat is feebler than in the unstimulated period. This should be a warning not to prescribe alcohol in the early stage of acute diseases, lest the depression comes on before the crisis.

In enteric fever, alcohol is not necessary as a matter of routine. But it is of great value in continued high temperature, when there is a feeble running or dicrotic pulse, muttering delirium, muscular tremors, and other signs of great septic intoxication.

Alcohol is not essential in an ordinary case of pneumonia, so long as the heart is able to do its work, and the circulation is good.

[1] "Stimulants and Narcotics."

But if the heart begins to fail, a stimulant, not necessarily alcohol, is necessary. If the pulse becomes small, rapid, feeble, and irregular, the breathing embarrassed, the lips and nose cyanosed, the right side of the heart over-distended, all the help which can be obtained is necessary. There is no doubt that in such cases alcohol is a valuable ally and as necessary as strychnia, musk, ether, digitalis, and oxygen.

Alcohol is useful in other diseases. In many cases of insomnia a glass of whisky or stout is a good sedative. In neuralgia and other cases of nervous irritability a dietetic quantity of wine, ale, or stout, is beneficial. Its use in various conditions is mentioned under special diseases.

There are contra-indications to its use, such as diseases of the kidneys and urinary passages, the diseases peculiar to women, and especially the neurotic condition. The relief of pain, and especially mental suffering, by alcohol tends to its abuse. A special warning is necessary in view of the fact that female intemperance is rapidly increasing.

Respecting the use of particular alcoholic beverages, the following remarks should be read in connection with the foregoing account of the effects of alcohol.

Malt Liquors.—Beer, ale, and stout, by virtue of their taste, aromatic bitters and tonics, give a relish to food, increase appetite, and promote the flow of saliva. To this extent they assist digestion. They are useful to convalescents, those enfeebled by chronic diseases, and the aged. They are of some value to those whose occupation is sedentary, whose stomach has lost tone by overwork, rush, and worry, and to sufferers from neuralgia and insomnia. The limit should be 1 pint a day. They are contra-indicated in neurotic conditions, diabetes, gout, rheumatism, obesity, and genito-urinary diseases.

Cider and Perry are useful in some cases of gout, obesity, rheumatism, calculus, renal diseases, and occasionally in diabetes. *Dry cider,* being free from sugar, is the best. Rough cider is said to be particularly good for gout and rheumatism. Sweet and champagne cider are contra-indicated in gout, rheumatism, and diabetes.

Spirits.—The physiological action of brandy, whisky, rum, and gin is not due to alcohol alone. They contain ethers and aldehydes, developed during maturation. It is important that spirits should be of a good age, not less than ten years old. The ethereal products not only stimulate the heart, they influence the central nervous system and the vegetative functions. *Brandy* is the best spirit for most acute cases. Cognac and liqueur brandy are the best forms. Cheap spirits are injurious. The dose is 2 to 4 drachms every two or three hours, and the total should not exceed 4 or 5 ounces a day. The aphorism of Armstrong and Graves is of value: (1) *It is doing good* if the tongue becomes moist, the pulse slower and fuller, the breathing tranquil, and the skin moist; (2) *it is doing harm* if the tongue becomes dry and baked, the pulse and breathing quicker, the skin dry and parched. When the acute stage of a febrile disease

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is over, brandy is no longer necessary. But when the temperature becomes subnormal and the pulse is very feeble, good wine may be beneficial. Alcohol is only of temporary value, and its use should be discontinued as soon as possible.

In chronic diseases brandy is useful sometimes, especially for spasmodic affections, angina, syncope, etc. It is probable that the ethers and aldehydes contained are beneficial and have saved many lives.

Whisky is said to be the best alcohol in chronic pulmonary diseases; but it is useful in some of the cases where brandy is serviceable. It does not contain so much ether as brandy and rum, but there is more aldehyde, especially in pure malt whisky made in the pot-still. Whisky is allowed to gouty, rheumatic, and diabetic persons, and in some cases of atony of the stomach. "Low forms of bronchitis, congestion of the lungs, influenza, typhoid . . . cases of breakdown from overwork, all characterized by weakness of the heart, failing circulation, inability to take food, loss of power to sleep, and exhaustion, come into the category of suitable cases."[1]

Rum is not prescribed so often as brandy or whisky, although it is the richest in ethers, which suggests a medicinal use for it. It is a popular remedy for chronic cough and general debility, being frequently combined with raw eggs and spruce beer.

Gin has undoubted qualities as a stimulant, aromatic, anti-spasmodic, and diuretic. It derives these properties from the essential oils of calamus, angelica, grains of paradise, cardamoms, cassia, juniper, and coriander. Its range of application is wide. As a popular remedy its use needs to be restricted rather than encouraged. All kinds of gin are not equally palatable, but many of them make an agreeable beverage when diluted with sweetened water. The oil of juniper, which predominates in Holland gin, gives a less agreeable flavour.

Liqueurs all contain aromatics and carminatives similar to gin; but they are not all alike. Benedictine, Chartreuse, curaçoa, and absinthe have similar properties to gin, but are not diuretic. Green Chartreuse is made from balm, hyssop, peppermint, thyme, genepi, angelica, buds of poplar, cinnamon, and mace. Curaçoa from curaçoa rinds and fresh orange peel. Absinthe from wormwood, peppermint, anise, fennel, calamus, and lemon rind. Dutch bitters from curaçoa, calamus, socotrine aloes, and Brazil wood. Anisette from aniseed, almonds, coriander, fennel, bay leaves, nutmeg, etc. There are many liqueurs. Their composition and properties vary according to the whim or fancy of the manufacturer. Originally they were distilled, but now some of them are only tinctures of the herbs, and others are merely coloured solutions of artificial oils and bitters.

Wines.—When wine is prescribed for therapeutical purposes, it should be of good quality. To obtain such it is advisable to take the opinion of the salesman. **Claret** (the red and white Bordeaux

[1] Murray, "Rough Notes on Remedies," p. 125.

wines) is of value in all cases of debility, not merely as a stimulant, but as a genuine tonic and restorative. A true red claret is less stimulating than white claret, and much less so than either red or white Burgundy. This tonic property depends largely on the amount of tannin combined with a low percentage of alcohol. The composition of clarets differs very little, although the physical characters differ greatly. The wines of Chateaux Haut Brion, St. Emilion, and St. Raphael contain more tannin than any others. It is of value in cases of anæmia, general debility, overwork, enfeebled digestion, and similar ailments. When people are able to eat very little food in warm weather, and become debilitated thereby, it may be advantageous for them to take some claret with their meals. The astringent property of this wine renders it valuable in atonic and bilious forms of indigestion, diarrhœa, and relaxed conditions or passive congestion of all mucous membranes. It is better than malt liquors for persons inclined to obesity. Some writers say red claret should not be taken by gouty or rheumatic persons; but this is a mistake, if alcohol is allowed them at all, because it contains a smaller proportion of *fixed acid* than most wines, and is of low alcoholic strength. It is certainly better than malt liquors. White Bordeaux wines, or **sauternes** are of two qualities: the first growth of Haut Sauterne, Graves, and Y'Quem, are sweet and have considerable strength. They have a primary stimulating, and secondary sedative effect, and are recommended for nervous and excitable persons, of a thin and irritable disposition, and for pulmonary cases when exhausted by racking cough and want of sleep. They are not prescribed as a tonic or restorative, and they are contra-indicated by gout, rheumatism, diabetes, and obesity. Wines of the second growth are thin, acidulous, and contain only 1 grain of sugar per ounce. They are suitable for bilious persons and those who are obese or tend to get fat; and as an occasional beverage for the diabetic. They are unsuitable for anæmic persons whose tissues are soft and flabby; also for people with passive congestions, lax mucous membranes, a tendency to diarrhœa, or acid dyspepsia. Gouty people should take them with caution on account of their acidity, which tends to increase with age. **Burgundy** possesses more body, and is said to be more "generous" than claret; but it has not so fine a flavour and bouquet. It is more potent than claret, and is superior to other wines for anæmia, general debility, feebleness of constitution, and malnutrition, provided the alimentary organs are in good condition. It is not so good a stomachic as claret, because it contains less tannin. The stimulating effect is followed by a marked sedative effect, which is sufficient to enable it to replace bromide in some persons of a nervous and excitable nature with weak physical powers. It contains little sugar, and may be taken occasionally by diabetic and rheumatic persons. Gouty persons cannot take it with impunity, nor is it suitable for obese or plethoric people. Among the best Burgundy wines are Romanée, Clos de Vougeot, Chambertin, Musigny,

Richeburg, La Tâche, and Volnay. Maçon and Beaujolais are intermediate between claret and Burgundy.

White Burgundy wines (Chablis, Mersault, and Montrachet) vary in character; therefore care is necessary in prescribing them. They are more stimulating and exciting than white Bordeaux wines. They contain slightly less alcohol, but more acid. They should not be recommended as general tonics or even as refrigerants unless well diluted. They are apt to cause or aggravate dyspepsia, heartburn, and acidity, and are slightly aperient. They are not suitable for diabetic, gouty, or dyspeptic persons. As a tonic, red wines are preferable. Mersault and Montrachet are useful restoratives after acute diseases and operations, being preferable to sherry or port. **Moselle** is recommended for persons suffering from calculus, rheumatism, some forms of indigestion and intestinal diseases attended by constipation, and other diseases of metabolism. It is wholesome, light, agreeable, and has slight acidity. **Hock** has similar properties. **Tokay** contains a larger proportion of phosphoric acid than any other wine, and is a useful tonic. **Champagne** varies considerably in character and quality. The natural champagne, *vin brut*, has no added spirit or sugar. *Dry* champagne is allowed to persons suffering from gout, rheumatism, indigestion, and other diseases when a non-saccharine light wine is considered desirable. It is serviceable in acute illness attended by vomiting or heart failure, and in convalescence. Champagne which is acid, sweetened by sugar, and fortified with brandy, like the majority sold as a beverage, is injurious to the gouty, causes indigestion, heartburn, acidity, and other discomfort. **Sherry** contains more alcohol than the foregoing wines; it is also sweeter, and contains a high proportion of acids. Sweetness is due to added sugar; strength to brandy. It is rich in volatile ethers and aldehydes, which give it a special value in many cases of debility, nervous exhaustion, and convalescence, if a sweet wine is not contra-indicated. It is not suitable for diabetics. The high acidity contra-indicates it for gastric, gouty, and rheumatic persons. What has been said of sherry applies almost equally to **port**, which likewise contains a high proportion of ethers, aldehydes, alcohol, and sugar. The tannin renders it of value as a stomachic, and it is credited with making good blood; wherefore it is prescribed in anæmia, atony of the stomach, a relaxed state of mucous membranes, and muscular weakness. It is not suitable for persons suffering from gout, rheumatism, calculus, uric acid gravel, diabetes, and other disorders of metabolism. Tarragona port lacks the fine qualities of mature port; but when genuine, it has stomachic properties, and is of value in anæmia and general debility. Valdepeñas and Rioja wines are intermediate between port and claret as regards their characteristics and uses. The same remark applies to the red wines of Italy. Carlowitz, a Hungarian wine, is more distinctly of the port wine type; Malaga and Madeira wines are similar. Australian and Californian wines are near to Burgundy wines in character, and have similar uses.

Tea, Coffee, and Allied Substances.

The vegetable stimulants depend chiefly on **caffein** or **thein** ($C_8H_{10}N_4O_2$) for their most valuable properties. The proportion of caffein in tea varies from 1·35 to 1·75, roasted coffee 0·75 to 2·05, Guarana 5·0, kola 2·0, and maté 1·15, per cent. In cocoa it is replaced by 0·97 per cent. of **theobromin** ($C_7H_8N_4O_2$); and in khât (*Catha edulis*) by **katin,** which is allied to caffein. A small proportion of essential oil exists in most of these vegetables. That in coffee is an aromatic substance giving flavour to the beverage. These vegetables all contain some form of **tannin.** In tea it is pure tannic acid and gallo-tannic acid; in coffee it is caffeo-tannic acid. In tea the tannin averages 15 per cent., being only 6 per cent. in China tea, 10 per cent. in Indian, and may reach as high as 33 per cent. in Assam, and even higher in Young Hyson and Caper tea. The kind of tannin differs in various parts of the leaf. The woody fibre forming the mid-rib and veins of the leaves contains crude tannin or gallo-tannic acid, but in the edge of the leaves and between the veins it is pure tannic acid. The amount of tannin in the edge of the leaves reaches only 6 per cent.; the caffein in the same part reaches 3·5 per cent., and is much above the average.

Effects of Tea.—The proportion of tea commonly used is two teaspoonsful to a pint. The water should be fresh boiled and immediately poured over the leaves. It should be infused for three to five minutes, and then poured off. Long infusion causes a loss of the essential oil on which it depends for aroma. At the same time it extracts tannin, resinoid matters, gum, pectin, dextrin, and other matters which give "body" but add nothing to the refreshing qualities of the beverage. Tea is a stimulant and restorative of a high order. It removes the sensation of fatigue, clears the brain, and promotes intellectual activity. These effects are due chiefly to the action of the essential oil and caffein on the nervous system, and in a lesser degree to the hot water and sugar. It stimulates the general circulation, in consequence of which the flow of blood through the brain is quickened, its cells flooded with oxygen and food, and the products of metabolism removed. Caffein also rouses the nerve cells to activity and increases the power for mental and muscular work. It diminishes the tendency to sleep, and when taken to excess, may cause insomnia. McDougall, who physically investigated the effects of all the ordinary stimulants, found tea aroused the faculty of attention and association of ideas. Rivers[1] found "caffein increases the capacity for both muscular and mental work, the stimulating action persisting for a considerable time after the substance has been taken, and, with moderate doses, there is no evidence of reaction."

The effects of tea on the alimentary system should be noticed. It deadens the sensation of hunger, and enables the body to fast

[1] "The Croonian Lectures," 1906.

longer than it could without it. The tannin inhibits salivary and peptic digestion. The influence of tea in retarding the digestion of meat, fish, and other proteins is in proportion to the amount of tannin. Indigestion, atony, or catarrh of the stomach, is frequently due to excessive tea-drinking, and dyspepsia due to mental work, worry, or anxiety, is often kept up by tea and cured soon after its use is dropped. A cup of tea primarily encourages the action of the bowels in the same way as other warm liquids; but an excess of tea may cause constipation by its influence on the nervous system and the astringent effect of tannin. On metabolism the effect is not very marked. Caffein is destroyed in the tissues for the most part. Maly and Schultzkiver[1] found that when 0·10 gramme of caffein was taken internally, 0·066 gramme reappeared in the urine; but when injected subcutaneously, only 0·006 gramme reappeared in the urine. An ordinary amount of tea or coffee contains about 0·10 gramme of caffein, none of which can be detected in the urine as a rule; but when 0·5 gramme of caffein is taken, it can be detected. Caffein is closely allied to xanthin, and Bunge[2] says: "It is possible that the caffein molecule, in consequence of its similar constitution, has an affinity for the same elements in which xanthin is found, and that it plays an analogous but modified part. This may explain the stimulating action of caffein."

An excess of tea is injurious. The excitement of the nervous system may be carried to excess and result in insomnia, palpitation of the heart, flushing of the face, muscular tremors, and other signs of nervous irritability. Rivers[3] found that an excess of caffein has a very transitory stimulating effect, and may be an accelerator of fatigue, and "experiments suggest that caffein is a dangerous stimulant in cases of prolonged fatigue or in that tendency to fatigue which characterizes neurasthenia." Smoking tea in cigarettes is probably the most injurious mode of consuming it, the nervous symptoms being much increased.

Effects of Coffee.—Most of what is written about tea applies to coffee. It is aromatic and refreshing, enlivens the mind, stimulates mental activity, invigorates the muscular system, and removes the sense of fatigue. Its effect increases with the dose when it is taken in moderation. More coffee than tea is used to make an infusion. This should be borne in mind when comparing these beverages. The aromatic oil is dissipated by boiling, and the best temperature of the water is 210° F.—*i.e.*, not quite boiling. The excessive use of coffee leads to insomnia; indeed, many people who are not accustomed to it cannot sleep after taking a cup of coffee in the evening. Such persons are very liable to nervous symptoms after its use. It sensibly disturbs the heart, produces an uncomfortable feeling, causes it to become intermittent, and a sense of impending danger may arise. In other persons the circulation is improved, and a feeling of well-being follows a moderate dose of coffee. It has a

[1] *Monats. d. Chem.*, May, 1883.
[2] "Physiol. and Pathol. Chem.," p. 122. [3] *Loc. cit.*

beneficial effect on the respiratory function, the excretion of CO_2 being increased; the sweat glands are stimulated, and there is increased loss of heat from the skin. Thus coffee warms the body in winter and cools it in summer. Caffeo-tannic acid has a smaller effect in retarding salivary and pancreatic digestion than the corresponding principle in têa; but it retards gastric digestion more, and strong coffee or *café noir* has a still greater inhibitory effect. Its influence on the intestines is salutary, the morning cup of coffee being slightly aperient by increasing the peristaltic action. It is diuretic in proportion to the amount of caffein, due to its action on the nervous system and the renal cells.

Various brands of coffee *free from caffein* are sold. These lack many of the fine qualities of the genuine article, but they are useful for persons who suffer from nervous affections, insomnia, arteriosclerosis, etc., and who ought to be debarred from using ordinary coffee. Roasted coffee is frequently adulterated with chicory, dandelion, beetroot, figs, acorns, mangolds, turnips, and cereals. These substances, when roasted, give colour and body to the infusion, but are devoid of caffein.

In the treatment of disease coffee may be prescribed as a cardiac stimulant in dropsy, whether due to failure of the heart, kidneys, or liver. It is most valuable in chronic alcoholism, asthma, influenza, fevers, shock, or collapse, opium-poisoning, coma, and various other acute conditions. It may be used to vary the milk diet in many cases of illness. Its restorative action raises the spirits and cheers the individual who is depressed by his health. It is of especial value in melancholia, and other states of depression. For nervous headache and migraine its value is well established. But experiments led Rivers to conclude that caffein is a dangerous remedy in "that tendency to fatigue which is characteristic of neurasthenia." It is beneficial to the gouty by virtue of its action on the kidneys, but it may upset their digestive organs. When this occurs, coffee free from chicory and other adulterants should only be allowed. Acorn coffee is valuable in cases of chronic diarrhœa.

Maté, or Paraguay tea, of South America and Apalache tea of North America consist of the leaves of varieties of *Ilex*, which are dried, roasted, and reduced to coarse powder. They contain 1·25 per cent. of caffein, 7 per cent. of tannin, and a yellow volatile oil having stimulating properties. **Guarana** from *Paullina sorbilis* contains about 5 per cent. of caffein. These substances are used as ordinary beverages in their native country. In Europe the infusions are chiefly used as a remedy for migraine, but they are useless against headache arising from gastric and hepatic disturbances. **Kola** contains a glucoside, *kolanin*, which splits under the influence of an enzyme into caffein, kola-red, and glucose. It also contains a small amount of theobromin, which places it in an intermediate position between coffee and cocoa. Like tea and coffee, it enables the consumer to bear fatigue during prolonged fasting by increasing

the power of endurance for mental and physical strain. It is a stimulant and restorative of high value, especially after influenza, in myocarditis, bradycardia, mental depression, etc.

Effects of Cocoa.—It is something more than a stimulant: it is a food. It contains 7·5 to 16·5 per cent. of starch, 7 to 20 per cent. of nitrogenous matters, and 27 to 52 per cent. of fat. The active principle is theobromin, of which it contains 0·65 to 2·25 per cent. Cocoa is not so stimulating as tea, coffee, and kola, but it is more nourishing. In its natural condition it is not easily digested, because of the fat. But most commercial varieties have a considerable proportion of fat removed, and may contain as little as 20 per cent. According to Cohn,[1] most of the fat and half the protein is digested. Prepared cocoa usually contains added sugar; natural cocoa contains only 1 or 2 per cent. of dextrose and 0·25 to 1·5 per cent. of saccharose; prepared cocoa has 25 to 30 per cent. of saccharose (cane-sugar), and the same amount of starch. The action of **theobromin** or dimethyl xanthin on the muscles and nerve centres is similar to that of caffein and xanthin,[2] with this difference: its action on the central nervous system is less pronounced; its effects on the muscles, heart, and kidneys is more pronounced. As a drug it is used principally as a diuretic. Therefore cocoa may be prescribed safely in those cases where tea and coffee excite the nervous system, cause palpitation, nervous tremors, and insomnia. It may likewise be prescribed as a beverage in dropsy and heart failure. Prepared cocoa cannot be allowed to diabetics, but **cocoa-nibs,** consisting merely of the seeds, hulled, crushed, and roasted, may be used by them. A decoction is made by boiling cocoa-nibs in water for two hours, the dark brown liquid being then poured off from the residue. This beverage may also be allowed in renal diseases.

Coca.—The leaves of *Erythroxylon coca* are used to an enormous extent in South America. The physiological effects are due to the alkaloids, which place it in the same category as tea and coffee. The leaves contain cocain, cinnamyl-cocain, iso-atropyl-cocain, and tropa-cocain, besides coca-tannic acid, wax, and various crystalline bodies which are not alkaloids. The power of coca to prevent or remove fatigue is well established; but commercial leaves are not so active in this respect as fresh dried leaves used in their native country. It enables the body to endure prolonged exertion without food, and prevents nervous and muscular exhaustion. But while it prevents nervous exhaustion, dulness, drowsiness, and languor, it does not stimulate the mental faculties in the same degree as tea or coffee. Indeed, the excessive use of coca considerably diminishes the intellectual powers, and deteriorates the moral faculties. This is said to be due to iso-atropyl-cocain, which benumbs the cerebral faculties, and may reduce the confirmed coca-chewer to mental imbecility. Cocain is likewise capable of

[1] *Zeit. f. Physiol. Chem.*, xx. 1-27.
[2] Filehne, Du Bois Raymond's *Archiv.*, 1886, 72.

causing insomnia, hallucinations, delusions, muscular inco-ordination, tremors, convulsions, etc. Coca-wine, cordial, elixir, and infusion are valuable remedies for nervous debility, mental strain resulting from overwork or worry, cardiac weakness, bradycardia, tachycardia, and convalescence. But the patient should not be allowed a free hand in using them. Symptoms of the cocain habit begin with disorders of digestion, loss of appetite, and emaciation; the heart soon becomes feeble, irregular, and intermittent. This is followed by nervous symptoms and perhaps moral depravity.

Tobacco.—The physiological effects of tobacco are—(1) A short period of stimulation of the nervous system followed by depression; (2) a similar stimulation of the sympathetic system followed by lasting depression; (3) an action like curare on the terminal plates of the motor nerves in the muscles; (4) when death occurs it is due to failure of the respiratory movements. Tobacco first slows the heart and prolongs its contraction; the blood-pressure is raised by the constriction of the arterioles, due to primary excitation of the vasomotor centres. It thereby temporarily increases the flow of blood through the cerebral arteries, and stimulates the brain by the free supply of oxygen and nutritive pabulum. To this extent it aids the intellectual faculties, but that it stimulates the cells of the cortex cannot be conceded. The secondary effect on the nervous system is sedative, whence it may be said "it soothes and cheers the weary toiler and solaces the overworked brain." Many men of large intellect are great smokers, and the beneficial effect is probably due to a direct sedative effect on the nerve cells. When the smoking is carried to excess, it causes degeneration of the same cells, and leads to loss of power of thought, enfeeblement of the attention or power of concentration, and deterioration of the memory. It is neither a food nor a stimulant to the muscles. Rivers showed by the ergograph that it has an unfavourable effect on muscular work. This is to be expected from its action on the nerve-endings in the muscles. It relieves the sensation of hunger and enables the smoker to endure fasting. A pipe of tobacco after a meal, by suppressing the inhibition of the vagus, causes the gastric mucous membrane to be flushed with blood, the gastric juice to be secreted freely; the intestinal secretions and movements are likewise promoted. But long-continued and excessive use of tobacco causes a diminution of the gastric and intestinal secretions and movements. Dyspepsia and catarrh are induced, and nutrition is impeded. The assimilation and metabolism of nitrogen is lowered.[1] The heart-beat is first made slower and stronger, but owing to its influence on the vagus, it soon becomes quicker and often beats 25 to 50 per cent. more frequently than normal. Excessive smoking increases the excitability of the heart, it becomes intermittent and irregular, and in some cases tachycardia, in others bradycardia, is

[1] Gramstchikov and Ossendovski, *Vratch*, vii. 45-46.

developed. Tinnitus aurium occurs, and amblyopia or amaurosis with a central *scotoma*, is quite common.

What is a moderate amount of tobacco ? This question is not easy to answer. There are men who smoke 2 ounces of tobacco a day in a pipe, others use 10 to 15 cigars, or 80 to 100 cigarettes. These are examples of excess. As a general rule 2 ounces of tobacco in a pipe would be enough for one week; but, like other stimulants, an excess for one man would not affect another. The injurious effects of tobacco have been attributed to various principles. The juice from 10 kilos of tobacco yielded 1,000 grammes of nicotine, 20 grammes of nicotiene, 5 grammes of nicotinine, and 1 gramme, of nicotelline. Nicotine is the principal agent. French tobacco contains 7 or 8 per cent., Virginian and Kentucky leaves 6 or 7, and Havanna only 2 per cent. Nicotine is only partially destroyed by smoking. Some authorities found only 50 per cent. was broken down; the rest is inhaled. The smoke contains nicotine, pyridine, hydrocyanic acid, ammonia, and carbon monoxide. Nicotine is a powerful poison. Pyridine is also a poison. It paralyzes sensation. Small doses stimulate and large ones paralyze the heart muscle. Gawalowski considers it forms a combination—nicotine-pyridyl carbonate—which is the injurious principle in smoke. Thoms considers an ethereal oil is produced which causes giddiness, headache, and muscular tremors. The carbon monoxide is perhaps too insignificant to have a serious effect. The same remark probably applies to the trace of arsenic which has been detected in tobacco.

Spices and Condiments.

The essential principles in our food are, for the most part, devoid of taste. Proteins are insipid and odourless, and fats are tasteless when quite pure. Sugars alone of the carbohydrates have a sweet and agreeable taste. With the exception of this class of materials, our essential foodstuffs, when pure, would soon pall on the palate, and, by monotony, lead to satiety and disgust. Nature wisely mingles with them various aromatic and savoury bodies which give taste and odour to our foods, and increases the desire for, and pleasure in, eating them. So keen is the effect produced by some of these flavouring agents, that the thought, smell, or taste of them produces a desire to eat and a flow of the digestive secretions. The aromatic substances in meat, the odour of fruit, and the flavour of many other articles is due to volatile agents which produce a pleasant effect on the organs of sense, enliven the mind, and promote appetite, so that they may be regarded almost as essential as the food itself. Man, however, is not satisfied by the natural flavour and aroma of his food, but consumes many condiments and spices which have a similar effect on his senses.

It should be noted that some condiments—sugar, molasses,

[1] *Oest. Zeit. f. Pharm.*, lvi. 432.

syrups, jam, marmalade, and honey—have likewise a genuine food value. Extracts of meat, on the other hand, like salt and vinegar, are almost purely condimental. The small piece of cheese eaten at the end of dinner is a condiment of equal value. Common salt is largely used as a condiment. It not only promotes the consumption of food, it encourages the secretion of gastric juice, and furthers the solution of proteins. Bunge says more salt is necessary in proportion to the amount of potassium in our food, sodium being an antidote to potassium. Common salt, sodium chloride, exerts a favourable influence on metabolism. An average of 9·5 grammes leaves the body in the urine and 0·05 gramme in the fæces—therefore a total of 150 grains of salt daily is enough. Many people consume a greater quantity, but it should be remembered that when the kidneys are defective, the excess may be retained in the body and lead to anasarca. Vinegar is used to a less extent, and is not injurious in moderation. Pickles derive their appetizing properties partly from vinegar and partly from spices. It provokes appetite, and a tired person may eat more when it is used. Persons who suffer from weak digestion should avoid vinegar and pickles. The acetic acid retards salivary digestion, and irritates the gastric mucosa. Later on it is converted into an alkaline carbonate. An excessive consumption of vinegar causes "anæmia and emaciation; the acid tends to lessen the alkalinity of the blood, and the number of blood-corpuscles."[1]

The other condiments fall into two groups: the aromatic spices and sweet herbs. Aromatic spices include mustard, pepper, horse-radish, cayenne pepper, ginger, cloves, allspice, cinnamon, nutmeg, garlic, and onion. Their properties are derived from alkaloids and oils. The majority of physicians are in favour of their *moderate* use. They rouse a flagging appetite, promote the secretion of saliva and gastric juice, stimulate the movements of the stomach and bowels, and assist digestion in general. They are disinfectants and deodorants. They subdue irritability by producing a sensation of warmth, and prevent or relieve griping from various foods. They stimulate the visceral circulation, promote leucocytosis, and favour metabolism. Against *abuse* it is urged that excess causes hyperæmia of the liver, catarrh of the alimentary mucosa, hæmorrhoids, and interfere with nutrition. Korczynski found by experiment that they promote the motor functions of the stomach, but over-stimulate the secretory glands, and finally inhibit the formation of hydrochloric acid. Such spices should be forbidden in catarrh of the stomach and hypochlorhydria, but may be useful in hyperchlorhydria.

The sweet herbs include mint, thyme, sage, marjoram, savory, basil, bay-leaf, parsley, fennel, etc. Their flavour depends on terpenes and camphenes. They are soothing and carminative. They primarily constrict the arterioles; but they prevent griping,

[1] Bauer's "Dietary of the Sick."

relieve colic and flatulence. They are antiseptics. Many people cannot take them with impunity. They are too soothing, they check the intestinal movements and circulation, interfere with pancreatic digestion, reduce absorption, and promote constipation. Menthol, which is a type of the bodies in sweet herbs, according to Vladimirsky, diminishes the amount of free hydrochloric acid, hinders the transformation of proteins, and checks the motor activity of the stomach. They should be avoided by persons having weak digestion, and forbidden to those with hypochlorhydria. But ordinary persons may safely take them with meat, game, pork, veal, fish, and other animal foods.

PART II

CHAPTER IX

DISEASES OF THE STOMACH

Indigestion.

INDIGESTION is synonymous with dyspepsia, and signifies interrupted, delayed, laborious, or painful digestion of the food. It is a derangement of the processes which transform the food into chyme and chyle. With this meaning, indigestion is not confined to the stomach, but may affect the whole alimentary canal. The trouble, however, may be limited to one or another part of the canal —*e.g.*, the stomach, the duodenum, or some other portion of the small bowel. The causes are various. It may be due to excessive consumption of food, eating too often, or fasting too long; food too rich and well seasoned or coarse and too little seasoned. It may arise from lingering over the pleasures of a luxurious table or from hurriedly eating the plainest fare; excessive imbibition of wine or need of stimulant; *ennui* in the wealthy or weariness in the toiler; inactivity or overwork; excess of joy and pleasure or grief; worry and mental depression; indulgence in too much sleep or too little sleep; overheated, badly ventilated rooms in luxurious homes or exposure to cold and damp or living in poor surroundings.

Excessive consumption of foods and eating between meals overtaxes the alimentary organs. Hurried eating means improper mastication and deficiency of saliva; this is the beginning of trouble. When mastication is defective, not only is the saliva deficient, but there is a deficiency of gastric juice and especially of the *psychic* or *appetite juice*. If the psychic juice is deficient, there will be a deficiency of the *hormone* which provokes normal secretion of gastric juice; consequently the period of gastric digestion may be delayed an hour or two, and the imperfectly masticated material will cause pain, or distension by flatus will occur, and palpitation of the heart, shortness of breath, flushed face, and other symptoms.

Irregular feeding is distinctively conducive to indigestion; one meal only is as bad as six or seven meals a day. Eating between meals prolongs the digestive process indefinitely; the alimentary organs are never at rest.

Dyspepsia is frequently due to the constitution of the food.

New bread, hot cake, pyclet, crumpet, muffin, pastry, boiled dumplings, boiled suet puddings, "rich" foods, fatty foods, highly seasoned dishes, entrées, hashed meat, curry, sausage, pork, pork pie, veal, liver, kidney, brain, salted or pickled meat, crab, lobster and other shellfish, cheese, coarse vegetables, uncooked vegetables, salads, pickles, sauces, sweet dishes, and confectionery are a prolific source of trouble.

There can be no doubt of the deleterious effect resulting from the mixture of too many foods; but within moderate limits variety is beneficial, whereas monotony is detrimental. It should be added that one kind of food is not equally injurious to everybody; it is perfectly true that "one man's food is another man's poison." This is due to idiosyncrasy; a person who is upset by a teaspoonful of fresh egg might be able to eat cheese or pork pie with impunity. A moderate amount of veal or pork may cause serious indigestion in a man of forty; but a man of sixty-five or seventy years may not feel any ill-effect from it. Another person, who has heart-burn or acidity of the stomach after rice pudding, probably feels no ill-effect from apple pie and cheese. The excessive use of tobacco, alcohol, tea, spices, and condiments frequently causes indigestion.

Acute Indigestion occurs, for example, when an individual consumes an excess of food, or there is a disproportion between the food consumed and the digestive capacity. The latter circumstance may arise from bodily exhaustion, mental distress, shock, or worry. It may be due to the consumption of unsuitable foods—lobster, salmon, mackerel, pickles, pastry, ices, etc. The offending substance causes pain in the epigastrium, and sometimes vomiting or purging. When the symptoms are less acute, the pain may be accompanied by palpitation and irregularity of the heart, dyspnœa, flatulence, and restlessness. If the patient sleeps, he may talk or dream, and when he awakes he may have a disagreeable taste in his mouth, disinclination for food, and a headache.

The obvious remedy is an emetic. The pain usually ceases when the stomach is emptied. If vomiting does not occur naturally or after the emetic, give hot water frequently to encourage vomiting and cause expulsion of flatus; the addition of sodium bicarbonate or other antacid may be useful. Let the stomach rest from food for a few hours after it is cleared out; then give a light meal of milk and soda-water, or lime-water, or Perrier water. A few hours later a cup of tea and some dry toast may be taken; and later on a light meal of sole, plaice, or boiled fowl, mashed potato, and a tapioca or sago pudding. Ordinary diet may usually be resumed within thirty-six or forty-eight hours after the attack commenced; but the patient should be carefully instructed about his diet and a diet-sheet given him.

Chronic Indigestion, dyspepsia, or functional derangement of the stomach, is due to one or more of the causes detailed above.

The subject of chronic indigestion ought to have only three

meals a day—at 8 a.m., 1.30, and 7 or 8 p.m.; a cup of tea may be taken about five o'clock. A short rest should precede the midday and evening meals, and a longer rest follow them. The interval between the meals must be at least five hours, and a longer time is advantageous in bad cases. Mastication must be well and carefully performed. "Fletcherism" might be useful in bad cases; but due application of the rule of Sir Andrew Clark is sufficient for most patients—"that the mouth contains, or ought to contain, thirty-two teeth indicates that every mouthful of food should receive thirty-two bites." When swallowed, the food should be fine enough to go through a sieve. Defective teeth must be repaired or replaced.

If the indigestion is very severe, it may be necessary for a short time to allow the patient only soft foods—*e.g.*, milk diluted with an alkaline or gaseous water (lime, lithia, soda, or potash waters, Apollinaris, Perrier, Puralis, or Salutaris waters). After a day or two on milk the diet may be improved by adding peptonized milk, Benger's food, milk gruel, or other farinaceous food, boiled stale bread and milk, custard, junket, and jelly. When the stomach will bear these substances without pain or discomfort, the patient may have the food detailed for less severe cases.

In less severe dyspepsia and in all cases while attention is being given to the teeth, the food must consist of articles which require very little mastication—stale bread (free from crust), biscuits or crackers (which will readily break down to powder in the mouth —*e.g.*, Marie or cracknell); omelette; egg-snow and custard; raw eggs in milk, milk; soup, broth; consommé, scraped meat, pounded chicken, chicken panada or soufflé; sole, plaice, whiting; mashed potato, vegetable purée, spinach, vegetable marrow; stewed fruit, cooked apples, milk puddings, baked custard, junket, and jelly. By-and-by the breakfast may consist of rusk or stale bread, lightly boiled or poached eggs or an omelette, and the midday meal may include a slice of underdone meat from a joint, the breast of a fowl, and other forms of fish, such as turbot, brill, cod, or young halibut. The evening meal should consist of similar articles. At breakfast some China tea or other tea containing a minimum of tannin may be taken. Water is the best beverage for lunch and dinner. A tumblerful of hot water, sipped slowly before the meal, cleanses the mucosa and refreshes it. When taken four or five hours after a meal, it hastens the final stages of gastric digestion, dispels flatus, and corrects acidity; a cupful of tea about 5 p.m. has the same effect.

In ordinary indigestion or dyspepsia the food should be as follows: Bread a day or two old; it ought to be light and porous, crumble easily in the fingers, be readily penetrated by fluids, but should not form coherent masses when rubbed in the hands. New bread should never be eaten; it forms tough or putty-like masses which resist dissolution and digestion.

Soup and broth of a proper kind may be taken, made from bones, beef, mutton, veal, chicken, rabbit, clam, or turtle. It should never be made from scraps of previously cooked meat, or from game which

is "high." The materials must be fresh—*i.e.*, free from taint of putrefaction. Consommé or purée is proper; in fact, the dyspeptic ought not to eat the vegetables boiled in broth or soup unless they are reduced to a pulp and put through a sieve.

Fish of the lighter kinds is always permissible—sole, plaice, whiting, *fresh* haddock, turbot, brill, flounder, perch, bass, cod, weak-fish, and practically all fish containing less than 2 per cent. of fat. Fish containing a higher percentage of fat as a rule are more difficult to digest; therefore herrings, bloaters, mackerel, eels, salmon, etc., must be avoided by the dyspeptic. Boiled whiting is the lightest fish; its fibres are soft and disintegrate easily. The ordinary sauces must be forbidden, but some butter and a few drops of vinegar or lemon juice may be allowed.

As a rule mutton is better than beef for the dyspeptic; its muscular fibres are shorter and ought to digest quicker than those of beef of the same age. Many people prefer beef. Whichever is used must be tender, and every piece of gristle and skin should be cut out, because the stomach cannot digest such materials, and they give rise to pain and discomfort. It is not necessary for the meat to be consumed on the day after it is killed; putrefaction does not begin so soon. On the contrary, meat which has been carefully stored for some days, while remaining free from putrefaction, becomes more tender and easier to digest through the action of lactic acid upon the sarcolemma of the fibres. The undercut of beef and the subscapular portion of mutton are particularly recommended. Tripe, sweetbread, boiled fowl, and rabbit are useful foods. Pheasant, guinea-fowl, breast of turkey, and grouse are better than partridge, hare, venison, and dark-fleshed game.

Potatoes should be mashed, preferably by a wire masher. Carrots, turnips, swedes (*ruta baga*), skirret, salsify, and other roots should only be eaten in the form of purée. The same remark applies, as a general rule, to cabbage, savoy, Brussels sprouts, and kale; but spinach, cauliflower, young and tender spring cabbage, green peas, and kidney (string or snap) beans, and vegetable marrow (squash), may be eaten in their ordinary form. While the indigestion is really bad, all fruits should be cooked; when the dyspepsia is less severe, a few uncooked ripe strawberries, raspberries, cherries, grapes, oranges, a pear, or even a crisp and juicy apple, may be eaten.

It should be again observed (see Digestibility of Foods) that root starches are digested more easily and leave a smaller residue than cereal starches, and that tapioca, sago, arrowroot, *tous le mois*, *poie* (taro), and potatoes are the best sources of carbohydrate for very severe cases of dyspepsia In less severe cases rice (which ranks next to them) may be taken. Wheat-flour, oatmeal, and barley-meal require a longer time for digestion; but during prolonged cooking the starch granules are burst, the cellulose envelopes softened, and some of the starch is transformed to dextrin. An average dyspeptic person may have all kinds of milk puddings (rice, sago, tapioca, oatmeal, barley, or bread), cornflour mould, arrow-

root, blanc-mange, or jelly, apple charlotte, custard, egg-snow, junket, and cooked apples, plums, prunes, etc.

Vegetarian Dietary for Dyspepsia.—There are some cases which do not improve with ordinary dietary, and the reason is sometimes difficult to discover. Some of these dyspepsias owe their origin to gout or some central nervous trouble. They may do better when meat is abstained from entirely for a few weeks; in fact, a course of vegetarian or purin-free diet may be essential. The proteins should be obtained from a purée of haricot beans, lentils, or chestnuts, but a pint or two or milk and one or two lightly boiled eggs may be taken daily. The rest of the food should consist of dry toast or bread-crust, oatmeal, pearl barley, maize-meal, macaroni, vermicelli, spaghetti; butter; French vegetable soup; purée of turnips, carrots, and herbs used for making soup; kidney (string or snap) beans, green peas, spinach; and all kinds of cooked fruit. Care must be taken that the food is properly balanced; vegetarian diet is practically of a low protein character.

The Meat Cure.—The Salisbury treatment (*q.v.*) is also useful for gouty dyspeptics and others who are overburdened with fat, suffer from pain, acidity, and fermentation, by removing all fermentable carbohydrates and reducing the diet to the greatest simplicity—*meat and hot water.*

In all cases the excessive use of tea, coffee, alcohol, and tobacco must be avoided. Tea taken at the same time as meat hinders its digestion; but a cup of tea or coffee three or four hours after a meal hastens the final stages of gastric digestion—hence the value of a cup or two of tea about 5 p.m. It is better to drink nothing at all while eating; let the food be well masticated and the saliva given an opportunity to work. The patient may drink about ½ pint of hot water a short time before each meal, or the same amount of cold water at the end of it. By the former method the mucous membrane will be washed and liberated from the residue of the previous meal; by the latter, flatus will be dispelled and thirst quenched.

The use and abuse of alcohol has been considered under that heading (p. 250). A small quantity of sound wine or well-diluted spirit will be beneficial to many people; but an excess will hinder digestion. Bordeaux or Burgundy wines, or pure malt whisky made in a pot-still, are the best. A glass of light ale, beer, or stout, may be beneficial by raising the appetite and stimulating the digestive secretions of a person fatigued by work. It is the abuse of such beverages the physician must constantly bear in mind; it causes degenerative changes in the gastric mucous membrane, hyperæmia of the liver, secondary catarrh of the intestinal mucosa from passive congestion, and other sequelæ. The section on alcohol should be read.

Articles to be forbidden.—The patient should scrupulously avoid rich soups, gravies, and sauces. A small quantity of soup at the beginning of dinner stimulates the secretion of gastric juice, but a

larger quantity would hinder digestion. He must also avoid veal, pork, sausage, duck, goose, forcemeat, liver, kidneys; foods cooked in fat (fried foods); pickled and salted meat or fish; crab, lobster, shellfish; cheese; hot buttered toast, pyclets, muffins, crumpets, or other hot cakes, and new bread; pastry, boiled puddings, rich cakes, sweetened dishes, jam, candy, and other confectionery. Some reason is necessary for excluding many articles.

Fat is not digested in the stomach, except that the cellular membranes are dissolved and the fat liberated. Gastric juice contains *lipase*, a fat-splitting enzyme; but Volhard says it only acts on fat in the form of an emulsion—*e.g.*, egg-yolk, milk, cream. These foods rarely disagree when taken in moderation; but rich fatty foods cause indigestion in two ways: (1) Much fat checks the secretion of gastric juice and favours bacterial fermentation; (2) it hinders digestion by preventing the access of gastric juice to the foods. In pastry, buttered toast, cake, crumpets, other rich carbohydrate foods, pork, duck, goose, fat fishes, etc., the fat is intimately blended with the particles of flour or fibres of meat, and the gastric juice cannot get at the proteins until the fat is dissolved out; these foods, therefore, must pass into the intestines before they are digested, unless they remain in the stomach long enough for the removal of the fat which invests them.

Salted, pickled, or dried meat, is less easily digested than unsalted meat. Salt and saltpetre harden the muscular fibres and prevent the gastric juice loosening their connections and digesting them. The **collagen** of connective tissues is usually converted by gastric juice into gelatoses and peptones. The gelatoses (proto- and deutero-gelatose), according to Chittenden, do not differ essentially from the digestion products of gelatin. They are soluble, and easily pass out of the stomach; but when the fibres are inaccessible or harder than usual, the gastric juice cannot penetrate them, and digestion is hindered. Animal cell membranes, including sarcolemma, resemble either **elastin** or **keratin.** When meat is young and tender, its cell coverings resemble elastin, which is soluble; when it is old and tough, these membranes become more or less like keratin, which is insoluble. Salt and saltpetre cause these membranes to become much more like keratin than elastin. Sugar is frequently mixed with salt to prevent this effect, and when meat is preserved with sugar only, its fibres remain softer and moister and easier digested than that preserved with salt and saltpetre.

Cakes and other sweet foods are usually compounds of flour, eggs, sugar, butter, or other fat. They are highly nutritious, and many people can consume them regularly with impunity; but other people have heartburn, acidity, and other evidences of indigestion after eating them for a few days. One cause of indigestion has been referred to—viz., the flour is saturated with fat. The excess of sugar is another cause. Under ordinary circumstances some portion of the cane-sugar is inverted to dextrose or maltose by gastric juice acting in the presence of mucin; but the frequent

presence, or a temporary excess, of cane-sugar leads to a disproportionate secretion of mucus. This hinders digestion by enveloping the food and preventing the access of gastric juice. Aitchison Robertson[1] showed that the power of the stomach to invert cane-sugar is diminished in chronic dyspepsia and other gastric troubles, and if a solution of cane-sugar is taken after washing out the stomach, it causes pain, heartburn, and flatulence; but a solution of invert-sugar does not cause these symptoms. This evidence confirms clinical experience that dyspeptics ought to avoid sugar, jam, marmalade, syrups, sweet cakes, and other foods sweetened with sugar. On the other hand, honey, treacle (molasses), maple-syrup, and other substances containing a large proportion of invert-sugar (dextrose, levulose, and maltose) are much less likely to cause pain, flatulence, and acidity, and may be taken with impunity by most dyspeptics. It should be pointed out that many saccharine fluids sold as golden syrup, amber syrup, or syrup, are merely concentrated solutions of cane-sugar, and only contain the small amount of invert-sugar which has been produced by heat during concentration.

Vegetables.—The cell membranes of plants are not digested in the stomach; they consist of cellulose. When the cells are young, these membranes are thin, and the valuable juices, salts, and soluble carbohydrates are removed by osmosis and diffusion. When they are cooked, such cells are burst by heat and expansion, the gastric juice obtains access to the interior, and the substances are digested; but as the cells increase in age, the cellulose covering gets thicker, the fibres more or less covered with lignin (*ligno-cellulose*), and the tissues are neither softened nor loosened by gastric juice; they cause pain and discomfort, and, in common parlance, are indigestible. When such vegetables are boiled, the action of heat and water softens the cellulose and loosens the fibres to a considerable extent, but they are not nearly so easily digested as young vegetables, and they still cause pain and other symptoms of indigestion; therefore all dyspeptics must be forbidden to eat salads, pickles, uncooked vegetables, most uncooked fruits, and nuts. The cooked vegetables and fruits indicated above may be consumed; but cabbages, savoy, carrots, turnips, parsnips, celery, yams, sweet potatoes, and Jerusalem artichokes must be forbidden or reduced to purée by rubbing the cooked vegetables through a sieve.

Spices and Condiments.—The abuse of these substances is a well-known cause of indigestion. Their moderate consumption by ordinary people need not be interdicted. Certain people need the slight stimulation which results from their use. Mustard, pepper, ginger, cloves, allspice, horseradish, cayenne pepper, onions, and garlic have a dietetic value which should not be under-estimated; but this value is seldom taken into account. By their presence in food they excite the nerves of taste and smell, and cause a sensation of hunger, increase of appetite, and a desire for food. They stimulate

[1] *Brit. Med. Jour.*, 1904, i. 22.

the salivary and gastric secretions; the motor activity of the stomach is promoted; they subdue the irritability of the stomach and bowels, relieve dyspepsia, flatulence, hiccough, and even spasm or cramp of the stomach. The griping pain following the consumption of vegetables, such as cabbage, cauliflower, peas, beans, artichokes, turnips, etc., is prevented or relieved, and intestinal digestion is promoted. The sweet herbs—mint, thyme, sage, marjoram, savory, and basil—have a different effect; they are antiseptic, carminative, soothing. They prevent griping or colic and relieve flatulence, but they depress glandular activity and slightly check the intestinal movements and absorption.

These effects should be carefully considered when dieting a dyspeptic patient. A moderate use of the first group of spices will be useful to such a person by stimulating the circulation through the vessels of the stomach and bowels, promoting secretion, increasing muscular tone, dispelling flatus, checking bacterial fermentation, and assisting absorption all through the alimentary canal; but their abuse is deleterious by overstimulation of the glands and causing catarrh, which ultimately results in failure of nutrition. Korczynski[1] found that mustard, pepper, ginger, etc., stimulate digestion by promoting motor activity; but they progressively impair the glandular functions and finally inhibit the secretion of hydrochloric acid. With regard to the second group, although they exercise valuable antiseptic, aromatic, and carminative properties of great value when game and other foods of a high character are consumed, they depress the glandular secretions, and check intestinal movements and absorption. Moreover, the observations of Vladimirsky[2] on menthol—a good representative of the essential principles of this group of spices—showed that it diminished the proportion of free hydrochloric acid in the gastric juice; that lactic acid rises in proportion to such diminution; under its influence the digestion of proteins was delayed and the motor activity of the stomach lessened, although absorption was promoted by stimulation of the circulation. The conclusion to be derived from the observation and clinical experience is that the second group (mint, thyme, sage, marjoram, basil, savory, bay-leaf, etc.) should be entirely prohibited to the dyspeptic person.

An endeavour should be made, where a person has habitually abused spices and condiments, to break the habit. A sudden cessation of their use would be injurious. The habit must be gradually broken, and the diet carefully arranged until the stomach has regained its tone and vigour.

Tobacco, like many other things, is not injurious when used in moderation; but excessive smoking may derange the functions of the alimentary canal. The secretions diminish, the peristaltic movements become slower and feebler, appetite fails, dyspepsia or

1 *Cf.* Germain Sée. *Semaine Méd.*, and *Brit. Med. Jour.*, October 4, 1900.

2 *Cf.* Germain Sée, *ibid.*

gastric catarrh appears, and nutrition is impeded. Dyspeptics should not smoke cigars or cigarettes, and they should limit their smoking to 2 ounces of mild tobacco in a pipe weekly.

Exercise in the open air is valuable to dyspeptics. The man of sedentary habits must exercise his body in some way. Walking is good; but most men prefer golf, bowls, tennis, quoits, croquet, badminton, shooting, or fishing. A tour in Derbyshire, Wales, West of Scotland, Switzerland, the Tyrol, the Rocky Mountains, and other mountainous districts is excellent for many men; but excess of exercise would be bad. There are some dyspeptics, sedentery people, whose heart is too soft and flabby to bear much walking or hill-climbing. A long sea-voyage would be preferable for them; if they are bad sailors, they may try the effect of a long motor tour. But they should be encouraged to take some exercise. Swedish movements or the Schott exercises and gentle walking on a low-grade incline must be insisted on when nothing else is suitable.

A course of mineral waters would be useful. It may be taken at Bath, Leamington, Malvern, or Harrogate in England; at Carlsbad, Marienbad, Kissingen, or Tarasp on the continent of Europe; at Bethesda Springs, Hot Springs (Arkansas), and other places in the United States of America; or Banff in the Canadian Rockies. Such waters cleanse the gastric mucosa, improve the circulation through the portal vessels, augment glandular activity, and remove the products of bacterial activity and faulty metabolism. Baths, combined with the Aix douche, massage, and galvanism would assist the cure. Some cases of chronic indigestion require months or years for complete recovery; but unless organic changes have occurred, the patient may be encouraged to hope for an ultimate recovery of good digestion and sound health.

Gastric Irritation.

Various functional and organic conditions are included in indigestion. The primary functional disorder of the stomach is gastric irritation. The food and food accessories bear the same relation to this disease as irritating gases and particles of matter inhaled into the lungs bear to bronchial catarrh or bronchitis. Gastric irritation includes gastric catarrh and what is usually described as "acid dyspepsia"; but the latter by no means includes all cases of gastric irritation, for the motor function as well as the secretory may be disturbed. Martin[1] considers there are two stages of the disorder: (1) In the first stage there is a varying degree of congestion and nervous irritability of the mucosa, increased and prolonged acidity of the gastric contents (*hyperacidity*), due chiefly to excess of hydrochloric acid (*hyperchlorhydria*), and a varying degree of weakness of the muscular walls (*atony*), which may lead to a moderate dilatation of the organ. (2) In the second stage of irritation there may be continued nervous irritability, but the

[1] "Diseases of the Stomach."

overworked organ shows a diminution of function (*gastric insufficiency*) characterized by diminished secretion of gastric juice or hydrochloric acid (*hypochlorhydria*), and greatly diminished motor activity (*myasthenia*), causing a delay in the passage of food through the pylorus, and terminating in dilatation of the viscus. Campanella classifies the symptoms which may arise from gastric irritation thus: (1) *Chemical:* hyperchlorhydria, hypochlorhydria, achlorhydria, and organic hyperacidity; (2) *sensory:* gastralgia, hyperæsthesia, anæsthesia, nausea, and abnormality of appetite—*e.g.*, anorexia; (3) *neuro-motor:* vomiting, pyrosis, spasm, cramp, atony, and motor insufficiency. Many of these functional disorders require treatment on special lines; therefore, when chronic indigestion is very persistent, an attempt should be made by test-meals and chemical reagents to ascertain the exact functional disorder. By these means the acidity and activity of the gastric juice may be tested, the motility or motor power of the stomach gauged, and also its power of absorption. The reader is referred to other works for these tests. The conditions are dealt with below.

Hyperchlorhydria.—This is a form of acid dyspepsia which affects half the dyspeptics between the ages of twenty and forty-five years. It is more common in men than women, especially in the strenuous man of business, the shopkeeper who works many hours, the hard-working student, the person who worries or suffers from anxiety. It is common in those who eat too rapidly or consume an excess of spices, alcohol, or tobacco. It is sometimes associated with chlorosis, ulcer of the stomach or duodenum, pyloric spasm, gastric dilatation, or gastroptosis. The local irritating effect of alcohol causes hypersecretion of the gastric juice, and especially of the hydrochloric acid. When long continued, the irritation causes gastric catarrh Spices produce the same effect as alcohol; but it is lessened when the spice is mixed with a large amount of food. Tea, especially those kinds containing much tannin, also irritates the mucous membrane and causes hyperacidity. Organic acids, although very valuable to the organism, often irritate the gastric mucosa and cause hyperacidity. Fruit and vegetables containing malic, citric, and tartaric acid are irritating; but those containing oxalic acid are more so. Hyperacidity may be due to nervous causes: grief, worry, anxiety. Martin[1] says: "The results of irritation of a living tissue depend not only on the strength of the irritant, but on the condition of the nervous system. A slight irritation of the nervous system is followed by large effects. In gastric disorders the hyperacidity may be due to the direct effect of local irritation or indirect effect through a disorder of the nervous mechanism, exaggerated examples being seen in neuroses of the stomach."

Hyperchlorhydria cannot be diagnosed by subjective signs; a test dinner and examination of the gastric contents is necessary. In this disease the gastric juice is abnormally free and strong; free

[1] "Diseases of the Stomach," pp. 68-71.

HCl begins to appear in ten minutes after a meal, and is excessive. What degree of acidity constitutes hyperchlorhydria is not easily answered. The acidity of normal gastric juice at the height of digestion varies from 40 to 60 degrees on Ewald's scale. A *total acidity* of more than 70, and *free* HCl of more than 50, give rise to symptoms of hyperchlorhydria. The hyperacidity is due to HCl and not to organic acids; the HCl may rise to 0·3 or even 0·6 per cent. and cause an acidity of 70 to 100 degrees on Ewald's scale. The patient has a good appetite, perfect digestion of protein foods, the stomach is empty when fasting, and there is no motor impairment as the meal passes out in the usual time. Meat, fish, fowl, eggs, and milk are digested quickly, and their presence gives temporary relief to the symptoms. Foods containing much starch digest slowly. When the stomach is emptied after a test dinner, the contents consist almost entirely of residues from farinaceous foods, as seen by the microscope and tests for starch. Of course, the presence of egg, milk, meat, or fish residues depends on the time which has elapsed since the consumption of the meal. Starch digestion is checked when the acidity rises to 0·12 per cent., and there may be some delay in emptying the stomach owing to pyloric spasm, due in turn to excess of starchy food.

As a general rule the patient has perfect comfort during the meal and for some time afterwards; but at the end of an hour or two there is discomfort on pressure in the epigastrium, more or less severe pain, heartburn, pyrosis, eructations of gas, and there may be headache, giddiness, vertigo, or palpitation, or a combination of them. It is relieved by taking a glass of milk or raw eggs to fix the acid, or sodium bicarbonate and waters containing it (Apollinaris, Vichy, etc.) to neutralize acid and check its secretion. The prognosis of primary hyperchlorhydria is good. When it is secondary to gastric or duodenal ulcer or organic change, the treatment and prognosis is that of the causative disease. Boas says it is not easy to decide whether the symptoms are due to functional derangement or organic change in the mucosa. The hyperacidity may be the initial stage of chronic glandular gastritis. The existence of disturbance of the motor power, the presence of an excess of mucus in materials removed from the stomach, and a history of the abuse of alcohol, tobacco, and spices, is in favour of the disorder being due to organic changes.

Treatment.—Hemmeter considers hyperchlorhydria is caused by the consumption of too much animal food, and the hyperacidity is an adaptation of natural means called forth by the frequent presence of an excess of protein foods. This is not true of all cases, for it is quite common in the poor, whose diet is of a *low protein* standard. There is little doubt that it is associated with imperfect mastication or bolting the food, or hurried eating followed by active movements, by habitual over-eating, indulgence in an excess of alcohol, tobacco, spices, tea, etc. The first thing to do, therefore, is to regulate the life and habits of the patient. Insist upon regular hours for taking

food, of eating slowly, masticating thoroughly, of regulating the temperature of food and drink; avoiding ices, fluids at too high a temperature, soups, meat extracts, spices, and all excess in eating and drinking, especially alcohol, tobacco, spices, tea, and coffee. Rush and hurry must be avoided; the overwrought must seek rest and change of air, and at the very least must rest for a short time after meals, and take out-of-door exercise.

There is a difference of opinion as to the form of diet most suitable for hyperchlorhydria. Some authorities consider nitrogenous food, and others carbohydrate, is the most suitable. In deciding the matter we should take into account the physiological effects of food in the stomach. Milk, bread, and other starchy foods cause but a small secretion of gastric juice; soups, meat extracts, fish, meat, and poultry cause a large secretion of gastric juice; fat and fatty foods tend to check the secretion of hydrochloric acid. Pawlow says the *chemical* excitants of gastric juice include water, substances in meat, meat extract, and milk. Fats have a retarding influence on the secretion, diminish the quantity of the juice, and the amount of the enzyme. Alcohol is a powerful provocative of secretion. When the influence of meat, milk, and bread is compared, it is found—

1. That the acidity is greatest with meat and lowest with bread.
2. The duration of the secretion and quantity of the enzyme is greatest with bread and lowest with meat.
3. That fats delay the appearance of the secretion, diminish the amount of the juice and the enzymes. According to Pawlow, even the presence of fat in the intestines has a reflex inhibitory influence upon gastric digestion.[1]

These observations are to some extent borne out by clinical experience. Carbohydrate foods are well tolerated if given in a suitable form, properly prepared, and carefully masticated. The indication, therefore, is to give an increased amount of amylaceous foods, which will be easily digested and assimilated, together with fats, especially butter and others which have a low melting-point, and are free from undesirable fatty acids, in such proportion as can be borne. Boas[2] agrees with the prescription of a fat and carbohydrate diet; but Strauss and Aldor[3] believe that the problem will be better solved by *reducing the amount of carbohydrates*, while providing in other ways a sufficiency of non-nitrogenous foods. The replacement of amylaceous foods by carbohydrates in solution would not satisfy the requirements; but Strauss maintains that the desired end is to be obtained by increasing the amount of fat in the food. He undertook a series of investigations on cases of hyperchlorhydria, by which means he showed that the addition of oil to the dietary was followed by a diminution of the total acidity and especially of the free HCl. Now, an excess of fat is known to

[1] Hammarsten's "Physiological Chemistry," p. 297.
[2] *Therap. Monats.*, May, 1906.
[3] *Zeit. f. Diet. und Physik. Therapie*, Bd. i., Ht. 2, S. 217.

impair the motor power and absorptive faculty of the stomach; but, on the other hand, it supplies the patient with an abundance of heat and energy-producing material which would otherwise be supplied with difficulty. Strauss and Aldor claim to have established the fact that in hyperchlorhydria there is a considerable tolerance of fatty substances, that the addition of 120 to 160 grammes of fat to the dietary is followed by no unpleasant symptoms; but, on the other hand, the nutrition and weight of the patient is improved. In their practice the additional fat was given in the form of milk, butter, cream, and oil, cream being especially recommended. Boas says lactic and butyric acids are well borne by such patients, and milk, cream, buttermilk, and kephir usually give rise to no unpleasant symptoms, and may form a considerable part of the dietary.

The propriety of giving a diet consisting largely of meat has been debated quite as freely as that of starch. Some authorities feed their patients almost entirely with animal foods and forbid starchy foods, the Salisbury diet being sometimes prescribed for six or eight weeks. They argue that the action of the salivary ferments is checked as soon as the food reaches the stomach, that intestinal digestion is defective, and therefore amylaceous foods are of little use to the organism. On the other hand, meat and other albuminous foods speedily absorb the gastric juice, fix the free HCl, and prevent or diminish pain and irritation. But if we continue to give protein foods in a supernormal amount, it is plain, although the free HCl is absorbed and fixed, that the hypersecretion will be encouraged, as Herschell says, by the law that Nature, when able to do so, responds to the demands made upon her. This continued call for HCl to combine with the albuminous material upon which we are feeding the patient will certainly tend to hypertrophy of the glandular elements of the gastric mucosa, and the last state of the stomach will be worse than the first. It is therefore probable, Herschell[1] says, that the disease will be perpetuated by a protein diet, and the alternative consists in the administration of a carbohydrate diet, consisting of substances partly dextrinized, at the same time neutralizing the greater part of the hyperacidity by drugs. Hutchison agrees that we must give a diet which will not lead to excessive secretion. However, he says that in the majority of cases it will be better to give such articles of food as will best tend to neutralize the acidity, and that the best regimen will be that in which milk, eggs, meat, and fish enter freely, whilst the starchy foods are kept within strict limits.

Rummo[2] says the aim of treatment is to regulate diet, neutralize excess of acid, and diminish oversecretion. Food should be taken at short intervals, well and carefully masticated, and of a non-irritating character; there should be a rest of one hour at least after each meal. Spices, aromatics, and excess of salt should be avoided. Drink should be insipid and not often changed, thereby avoiding

[1] *Brit. Med. Jour.*, 1898, ii. 1222-1226.
[2] *Rif. Med.*, October 24, 1910. *Cf. Brit. Med. Jour.*, 1910, ii., epitome 349.

any psychic stimulation of the stomach. *Much can be said for both the protein and the carbohydrate diets;* but the decision as to which should be used depends upon whether the hyperchlorhydria is temporary or more or less permanent, whether acute or chronic, whether there is greatly impaired motility, or a more or less permanent gastrorrhœa. *No general law can be laid down,* each case must be decided on its own merits, and each article of the dietary must be settled by reference to them. Meat, meat extracts, soup, alcohol, tea, and coffee are all powerful stimulants of HCl secretion; milk, eggs, white flesh, bread, and rice have a much less powerful effect on the secretion of HCl. A diet which is mainly albuminoid is well tolerated in acute and painful cases; but such a diet should be considered as one of urgency only, and should not be long continued. Fatty substances should be avoided in acute cases. The following is a dietary prescribed by Wegele:

Morning.—Two soft-boiled eggs; Aleuronat toast; tea and milk, 100 grammes.

Forenoon.—Raw ham, 100 grammes; oatmeal broth, 250 grammes, *or* Aleuronat meal broth, 200 grammes; cream, 50 grammes.

Noon.—Beef-steak, 150 grammes; mashed potato, 200 grammes; Aleuronat toast; white wine, 100 grammes, with Vichy, Bilin, or Saratoga water.

Afternoon.—Tea, 100 grammes; cream, 150 grammes.

Evening.—Cold meat, 50 grammes; two scrambled eggs; Aleuronat toast; wine, 100 grammes.

10 *p.m.*—Milk, 100 grammes.

Total Aleuronat toast, 100 grammes a day. Total value of diet, 2,400 calories.

I have not found it necessary in the majority of cases to give an absolute protein diet; indeed, I have had cases which only got better when meat and other animal foods were for a time stopped altogether, the carbohydrates and fats being correspondingly increased. The carbohydrates must be of such a character that they will be easily digested: good stale bread, milk puddings, blancmange, custards, oatmeal porridge, etc. Sweet foods are forbidden by most authorities, because they increase the total acidity; but whereas sweet cooked foods, cakes, etc., may give rise to severe heartburn, acidity, and pain, it is seldom that dextrose and maltose, when taken with other food, give rise to such symptoms. As a general rule, boiled eggs, *boiled* fat bacon or ham, tender meat, poultry, or fish are the best animal foods; but milk, junket, kephir or yaourte, cream, and buttermilk are permissible. Olive-oil can be taken freely with salads; butter should also be consumed freely. The fat checks the secretion of HCl and helps to nourish the body. Milk is usually agreeable to the stomach, and the organ is spared by it more than by any other protein food; indeed, an absolute milk diet with rest in bed is not an unsuitable beginning of treatment for bad cases. Max Einhorn says milk and boiled eggs should predominate in the treatment of such cases, although he allows enough bread to bring up the diet to proper calorie value, the bread being thickly spread with butter.

A controversy occurred over the number of meals such patients should take daily. Some physicians argue that two or three meals a day should be taken with an interval of five or six hours between each, eating between meals being interdicted. Others prescribe frequent small meals, the object being to diminish the acidity of the stomach by the addition of more food when gastric digestion is at its height; hence about six small meals daily, at about two and a half hours apart, meets this view, which is apparently that in most favour. With this object the following dietary is prescribed by Hawkins:[1]

8 *a.m.*—Hot water, 8 ounces, with a small dose of Carlsbad salts.

8.30 *a.m.*—Cocoa made with 10 ounces of milk, *or* the same amount tea (half milk); one or two eggs cooked any way; 2 ounces of Graham or whole-meal bread toasted, ¾ ounce of butter, ½ ounce of honey.

11 *a.m.*—Milk, 6 ounces; soda-water, 1 ounce.

1 *p.m.*—Meat, 2 ounces (veal, mutton, or ham by preference, *or* fish, game, chicken, sweetbread, or savoury omelette); toast, 1 ounce; butter, ⅓ ounce; custard or milk pudding, 2 ounces; cheese, ½ ounce; milk, 6 ounces, or plain or aerated water.

5 *p.m.*—Milk, 6 ounces; soda-water, 1 ounce; toast or rusk, 1 ounce.

7 *p.m.*—Milk soup, 6 ounces (flavoured with onion, celery, or turnips); meat or fish, 2 ounces (as at lunch); potato purée or lentils, 1 ounce; milk pudding, blanc-mange, custard or jelly, 2 ounces; toast, butter, and cheese or cheese-straws, as at lunch. Milk and soda, 6 ounces, or plain or aerated water.

10.30 *p.m.*—Milk and soda, 6 ounces.

Hawkins discusses the relative advantages of a protein diet and a carbohydrate diet. He says: " Protein food will relieve the discomfort which is the main feature of the malady, so that it would appear obvious at first sight that the diet should be mainly protein. . . . On the other hand, protein is a far greater stimulant of gastric secretion than carbohydrate food . . . so that by persisting in a protein diet we relieve the symptoms but perpetuate the malady. It is clear, therefore, that an amylaceous diet has a curative aim, while a protein diet is directed to the relief of symptoms." In severe cases of long standing he advises a " rest cure " of two or three weeks' duration. In the first week he allows 1½ to 2 pints of milk daily and nothing more. In the second week he adds to the dietary one or two eggs, poached, boiled, or scrambled, and towards the end of the week 4 ounces of milk pudding or rusks, bringing up the energy value of the food to 1,500 or 1,600 calories a day. In the third week he allows the patient to get up. The diet consists of 2 pints of milk, two or three eggs, 4 ounces of fish (sole, plaice, or whiting) or chicken, 3 or 4 ounces of toast or rusk, butter, custard, jelly, or blanc-mange, and cream. It may be necessary to continue this diet for some time; but as the gastric secretion returns to its normal limits the diet may be tentatively altered and extended. Starch, however, must continue to be dextrinized by dry heat, as in thin toast, rusks, crackers, zwiebach, or gelatinized by moist heat, as in milk puddings. Sugar may be freely used, preferably

[1] Sutherland's " System of Dietetics," pp. 506-515.

as honey or dextrose. Milk, junket, cream are proper foods; cheese straws and grated cheese are permissible. Eggs cooked in any manner are good. Butter is useful, as previously indicated. Jelly, calves'-foot jelly, cow-heel, and all gelatinous substances are proper foods. Tea (half milk), cocoa, milk and soda, plain water, Perrier, Apollinaris, and other table waters are the best beverages. The food should be taken warm when possible, not hot; about 100° F. Ices and very cold foods should be avoided.

The patient should be forbidden to take alcohol entirely until cured. Coffee should be avoided. Soups also should be avoided, primarily because they stimulate gastric secretion, and secondarily because of their low nutritive value. Pastry and cakes are taboo. Condiments and spices are forbidden for reasons previously stated, especially mustard, pepper, cayenne, horseradish, ginger, curry, vinegar, pickles, and sauces. The effect of salt has been much discussed. Hemmeter reduced the acidity of gastric juice in dogs by feeding them on meat deprived of salts by boiling it in distilled water. In a similar manner Cahn so far reduced the proportion of chlorides in the blood that the gastric juice secreted was a neutral and inactive fluid. The experiments show that pepsin is dependent on the presence of HCl, and the secretion of HCl on the existence of chlorides in the blood. It is rational, therefore, to restrict the consumption of salt by persons suffering from hyperchlorhydria, and in severe cases to order salt-free diet.

Raw fruits and vegetables must be forbidden, as well as cooked fruit containing seeds and vegetables having much cellulose.

The patient may have to exercise care in the choice of foods for a long time. Alcohol must not be taken until the cure is complete, but when there is no return of the symptoms, a little lager beer or dinner ale, diluted hock, moselle, or claret, or even a small amount of well-diluted whisky, may be allowed.

Hypochlorhydria.—There is a diminution in the amount of combined and free hydrochloric acid; the gastric juice is poor in quality. It is common in elderly persons with atonic dyspepsia or gastric catarrh; in others suffering from anæmia or general debility; and "weak digestion" may occur even in children, from a functional disorder characterized by a failure of the secretory and motor functions of the stomach. The condition varies from a slight diminution, or hypochlorhydria, to a complete cessation of the secretion of hydrochloric acid — achlorhydria or achylia. The digestion of food in the stomach is delayed or almost suspended; various forms of fermentation occur; the appetite is poor; the taste is often bitter, but may be unchanged; the tongue, usually coated, may be quite clean, or large, flabby, and marked on the edges by the teeth; the breath may be sweet or foul; a sense of fulness or flatulent distension follows eating, with eructations of gas or sour rancid liquid; there may be vomiting or entire freedom from nausea; diarrhœa may occur frequently, or there may be constipation.

Diminution of HCl plays a more important part in disordered digestion than excess of acid. There are three main causes: (1) Long-continued irregularities in the quantity or quality of food; (2) changes in the stomach: chronic hyperæmia, catarrh, atrophy of the glandular elements; (3) changes in the blood or nervous system. In acute catarrh of the stomach the secretion of gastric juice is almost nil, and during recovery pepsin may reappear before the acid. In infectious diseases HCl sinks to 0·006 per cent., lactic acid rising in proportion. The HCl is usually low in cases of active tuberculosis. In anæmia it is deficient if there is chronic indigestion, but in chlorosis it is often excessive. There is a marked diminution of HCl in cancer. But the most important cause of hypochlorhydria is chronic catarrh of the stomach.

The deficiency of HCl reduces the antiseptic power of the gastric juice, and various bacteria flourish. After the consumption of carbohydrates, according to Nothnagel,[1] a small amount of lactic and butyric acids normally occur; but in pathological conditions—*e.g.*, chronic gastric catarrh—the diminution of free HCl alters the reaction of the contents of the stomach, and all sorts of bacteria grow abundantly. The chief products are lactic and butyric acids; alcohol is also produced by yeast fungi and other bacteria, and in turn the alcohol is oxidized into acetic acid.

In a bacteriological examination of gastric contents obtained from thirty healthy persons by Capitan and Moreau,[2] only three kinds of micro-organisms were found—two being moulds and the other a bacillus. On the other hand, Abelous[3] obtained sixteen different micro-organisms from his own stomach: *Sarcina ventriculi*, *Bacillus pyocyaneus*, *Bacterium lactis aerogenes* (Escherich), *Bacillus subtilis*, *B. mycoides*, *B. ambylacter*, *Vibrio rugula*, besides eight other bacillary forms and one coccus. He investigated their action on foodstuffs. Casein was peptonized without coagulation by four kinds; nine kinds coagulated milk and dissolved the curd; four others coagulated milk but did not dissolve it. Many of the micro-organisms affected carbohydrates, including starch, cane-sugar, glucose, and lactose. The total result of such micro-organisms is acid fermentation, alcoholic fermentation, and putrefaction.

The antiseptic action of free HCl is therefore a necessity for healthy digestion. The amount normally present is 0·2 to 0·3 per cent., or 2·5 to 3·5 grammes per litre of gastric juice. In this proportion Miguel found free HCl will prevent putrefaction in bouillon, and Sieber found 0·5 per cent. of free HCl added to 50 grammes of finely chopped meat prevented putrefaction until the seventh day. But some of the above-mentioned micro-organisms were found by Abelous to resist the action of HCl (0·17 per cent.) for a long time, especially when they contained spores; and Macfadyen showed *Staphylococcus aureus*, *Micrococcus tetragenus*, and spores, readily pass through the stomach even during health.

[1] *Centralbl. f. d. Med.*, 1881, No. 2.
[2] *Compt. Rend.*, xli. 25.
[3] *Ibid.*, 86.

As a consequence of the deficiency of hydrochloric acid, protein indigestion in the stomach is very marked; but starch is very well digested in the stomach because the absence of free acid allows longer time for the action of ptyalin. Moreover, there may be motor insufficiency, and the food is not properly mingled with the gastric secretion. When HCl is less, lactic acid is more abundant; butyric acid, and, later on, acetic acid, carbonic acid, hydrogen, and other gases are then formed.

In the **treatment** of such cases the use of ferments and pre-digested foods has to be considered. The salivary ferment is not deficient, but attendant circumstances may prevent its carrying out its work; thus, imperfect mastication or defects in the teeth may cause an insufficient secretion of saliva. In such cases the use of malt diastase, malt extract, or taka-diastase is justifiable to assist in the digestion of carbohydrates. If the free HCl is deficient, it is useless to give pepsin; but the administration of hydrochloric acid may be useful. Respecting the administration of peptonized foods, peptones, or albumoses, it is superfluous to give them if the motor power of the stomach is good; if the motor power is deficient, they are useless, because Cahn has shown that practically no peptone is absorbed from the stomach. Pancreatin, useless as a rule because it is destroyed by the gastric juice, may be of service in cases of complete achylia.

The dietetic treatment consists, so long as the motor power is not defective, in the administration of carbohydrates and such proteins as will readily and quickly pass through the pylorus. Milk, eggs, meat reduced to a pulp and in small amount, the lighter kinds of fish, milk puddings, custard, junket, jelly, and stale bread, should form the staple articles. A dietary similar to the following may be useful:

Breakfast.—Two eggs (lightly boiled or poached), or 5 ounces of fish (sole, plaice, whiting, *fresh* haddock, brill, turbot, brook trout, bream, etc.), stale bread, dry toast, zwiebach; 7 ounces of milk, weak tea, or cocoa.

Lunch.—Soup; chicken, boiled mutton, or ham, 4 ounces; potato, spinach, vegetable marrow; milk pudding, custard, junket, jelly.

Dinner.—Soup; fish (any light variety), chicken, pheasant, breast of turkey, rabbit, lean mutton, underdone beef; potato purée, spinach, vegetable marrow; purée of parsnip, turnip, swedes (*ruta baga*); dry toast or zwiebach, sweets (as at lunch); dessert: a few grapes, a tangerine orange, one plum or apricot, etc. Bordeaux or other light red wine.

The food should be well salted to promote the secretion of HCl. A little soup at the beginning of lunch and dinner stimulates gastric secretion and assists in overcoming the hypochlorhydria; but, excepting a glass of red wine, the patient should take no other drink at these meals lest he dilute the already weak gastric juice. It is a good dietetic rule never to drink while eating, and only to take liquids a couple of hours after the meal, when thirst is actually felt. At this time, the gastric functions may be stimulated by drinking a cup of soup, meat extract, or some weak spirit and water. No solid food should be taken after dinner (7 p.m.). Mastication must be carefully performed, Clark's rule of masticating each mou th-

ful thirty-two times being properly observed, or "Fletcherism" may be adopted. Butter, excess of fat meat, and all greasy or rich food must be avoided. Green vegetables must be eaten sparingly, and all except spinach and vegetable marrow must be taken in the form of purée or consommé; coarse vegetables must be avoided. Spices and condiments may have a temporary beneficial effect, but are not recommended; pickles and heating sauces are forbidden (see Indigestion).

The hypochlorhydria may, however, resist a general dietary such as indicated above. The inadequate glandular secretion may be attended by defective motility. In such cases the patient should be confined to bed for two or three weeks and put on a milk diet. Robin objects to this method of treatment. He says: "We must discard milk; it diminishes the gastric and biliary secretions, causes constipation, induces intestinal paresis, and predisposes to irregular fermentations, which are particularly frequent in this kind of dyspepsia." But Hayem says milk is the most suitable food for all kinds of dyspepsia; it entails a minimum of expenditure, and is essentially unirritating; it is indicated in hyperpepsia (hyperchlorhydria) in which there is excessive stimulation, and in hypopepsia (hypochlorhydria), in which there is slow, laboured peptonization; it is better utilized than any food. In cases of hypochlorhydria which resist other forms of dietary it should certainly be tried. The patient should be confined to bed. The quantity of milk should be 2 or 2½ pints, gradually increased to 6 or 7 pints a day. It is usually borne well, except in cases of extreme dilatation and complete loss of motility or stasis. It may be given in doses of a tumblerful every hour, or 1 pint every three hours, according to the patient's choice. It should be given raw, boiled, or baked, and pure, or mixed with lime-water, salt, celery salt, meat extract, or an alkaline gaseous water; some patients prefer skim milk. The drawbacks from milk may be pain, flatulence, constipation, or diarrhœa. Pain is often due to the formation of curds; it may be prevented by lime or alkaline water, or sodium citrate. Flatulence is due to fermentation, for which various drugs may be required. If tolerance of milk is not established, we may resort to the use of kephir, yaourte, and other fermented forms of milk. The presence of the ferments and lactic acid assist in its digestion, and the lactic acid stimulates pancreatic secretion (Pawlow). According to Lyon, kephir does not remain in the stomach so long as milk. It is usually given with sugar or with seltzer-water. A combination of milk and kephir is useful in promoting tolerance and assisting to maintain the strength of the patient; but a milk or milk and kephir diet cannot be other than a temporary regimen, and more nourishing sustenance soon becomes indispensable. After two weeks on the diet we may add to it four or five lightly cooked or raw eggs. Thus, breakfast may consist of 1 pint of milk; lunch, of 1½ pints of milk and two eggs; tea, 1 pint of milk; supper, 1½ pints of milk and two eggs. The duration of this diet will vary with the progress of the case, and the

patient must ultimately be put upon the regimen first detailed. That dietary will have to be continued, modified, or suspended according to the progress of the patient. Should it fail, a lacto-vegetarian diet may be tried, or a course of treatment may be taken at Vichy, Pouges, Carlsbad, or Marienbad.

Organic Acidity.—The cause is *simple* when it is due to the presence of acids in the food—*e.g.*, vinegar, pickles, salads, cider, perry, acid wines, etc. Ordinary diet does not usually contain enough acids to irritate the stomach, but various causes lead to food containing an excess. Butter contains 7 or 8 per cent. of volatile acids, chief of which is butyric acid. Fresh meat contains 0·05 to 0·075 per cent. of lactic acid, but smoked meat may have 0·75 per cent. Fresh pork contains about 0·37 per cent., but sausages may have 0·75 to 0·85 per cent. Ordinary wheaten bread contains little acid, but sour bread contains a variable amount of acetic, lactic, and butyric acids. Green vegetables and fruit contain an abundance of organic acids and their salts, which frequently cause gastric irritation. Long-continued irritation by acid foods causes chronic gastric catarrh. The cause of acidity may be *chemical*—*e.g.*, transformation of alcohol into acetic acid—or *fungoid*, from the presence of *Aspergillus*, *Penicilium*, or other fungi in the stomach; and *bacterial*, from the presence of micro-organisms. The acids commonly produced in the stomach are lactic, butyric, acetic, and carbonic. When the gastric juice contains a due proportion of free HCl, it checks bacterial activity and prevents the formation of acids. The presence of lactic acid in normal gastric juice has not been proved; but when *free* HCl sinks below the proper percentage, lactic acid is always present. This does not come from the gastric glands, as it does in infancy, but arises from the unrestrained action of bacteria and fungi on carbohydrates. One molecule of dextrose is transformed into two molecules of lactic acid, and a molecule of lactose or cane-sugar into four molecules of lactic acid. Butyric acid originates from lactic acid, dextrose, or other sugar. The presence of such acids in the stomach causes heartburn, pyrosis, regurgitation of food, flatulent distension, cramp, spasm, palpitation of the heart, shortness of breath, and sometimes vomiting. If the acidity is fungoid, the vomit may be red or green, giving an appearance of blood or bile. If the acidity persists, it will cause gastric catarrh, and may lead to dilatation.

Treatment.—Organic acidity may be temporarily relieved by drinking water to dilute the acids at the time when gastric digestion is at its height; also by the administration of alkalies and alkaline waters. Free acids may thus be neutralized; but fermentation proceeds more rapidly than in their absence, because the growth of bacteria is favoured by an alkaline medium. The proper course is to rest the stomach by abstinence from food, until it has had time to become empty. A milk diet for a day or two is then useful. Afterwards the diet must be restricted to meat, fish, eggs, and green vegetables, *all farinaceous foods and even bread being banished for a*

time. After a carbohydrate-free diet has been used for a sufficient period, a gradual return to mixed diet must be made by allowing a small amount of easily digestible carbohydrate materials *at one meal a day.* When this tentative addition is borne without return of acidity, we may extend the dietary; but the use of sweet foods, pastry, rich or greasy foods, highly seasoned dishes, alcohol, and tobacco must be forbidden.

If, on the other hand, the fermentation occurs at the expense of the albuminoid substances of the food, a vegetarian diet is the best, consisting of beans, peas, and lentils cooked in salt water, fresh butter being added when they are eaten; but bread and farinaceous foods should be withheld for a short period.

Hydrotherapy is useful, especially sulphurous waters and those containing the iodides. A high and dry climate, like Buxton, the Malvern Hills, and other places, are useful aids in the treatment.

Flatulence.—The gases which arise in the stomach as the result of fermentation in that viscus are CO_2, hydrogen, marsh gas, and occasionally sulphuretted hydrogen; there are also the gases of the air or food which have been swallowed. In pathological conditions the amount of gas generated may be sufficient to cause dilatation of the stomach, especially when that organ is in an atonic condition. In such a case Kuhn[1] found the gas from the stomach had the following composition: $CO_2 = 20$, $O = 8{\cdot}3$, $H = 30{\cdot}9$, $CH_4 = 0{\cdot}3$, $N = 40$, CO = a trace, per cent. The oxygen in gastric flatus is usually from air which has been swallowed; it disappears almost entirely. Part is absorbed by diffusion into the tissues of the alimentary canal; part unites with the reducing substances in the stomach, and especially with the nascent hydrogen set free by butyric fermentation. Nitrogen also gains admission to the stomach by swallowing air. This gas does not diffuse into the tissues of the alimentary canal, because the partial pressure of nitrogen therein is nearly the same as in the atmosphere; on the other hand, nitrogen gas diffuses out of the tissues of the alimentary canal into its lumen. Hydrogen arises in consequence of butyric fermentation, and from the decomposition of cellulose in the lower bowel. Carbonic acid gas arises from the decomposition of carbohydrates and proteins in the stomach and bowels; but it is also generated in the neutralization of acid chyme and organic acids by the sodium carbonate of intestinal secretions.

The influence of these gases upon the comfort of the individual depends upon their coefficient of absorption. This was determined by Bunsen[2] to be as follows:

Coefficient of Absorption of Gases from the Alimentary Canal.

	Per Cent.		Per Cent.
Nitrogen	0·01478	Marsh gas	0·03909
Hydrogen	0·01930	Carbonic acid gas	1·00200
Oxygen	0·02898	Sulphuretted hydrogen	3·23260

[1] *Zeit. f. Klin. Med.*, 1892, xxi. 584.
[2] Bunge's "Physiol. and Pathol. Chem.," p. 278.

Carbonic acid gas may be generated in large volumes without causing great inconvenience, because it has a high coefficient of absorption. The partial pressure of CO_2 in the blood seldom exceeds 10 per cent. of an atmosphere; therefore, as soon as the partial pressure of the gas in the alimentary canal exceeds 10 per cent. of an atmosphere, it begins to diffuse into the blood, and is excreted by the lungs. The proportion of CO_2 in the gases of the alimentary canal varies from 20 to 50 per cent., and there is constantly an active diffusion of this gas into the blood, the lungs exhaling CO_2, which has been generated from food during the process of digestion.

Hydrogen, on the other hand, has a very low coefficient of absorption, because it exists in the blood and tissues in a nascent form, being dissociated from various substances by chemical changes going on therein. Its accumulation in the alimentary canal therefore gives rise to considerable discomfort until it is expelled. Nitrogen is only slowly absorbed and in very slight proportion, and, when atmospheric air is swallowed, this gas causes distension until it is expelled.

The coefficient of absorption of sulphuretted hydrogen is very high, more than a hundred times that of oxygen. In consequence of its very easy absorbability it is conceivable that the small amount of H_2S found in the intestinal gases gives no indication of the amount of this gas generated in a given time. It is probable that a good deal of H_2S is developed in the intestines during fermentation, and it diffuses into the blood almost as rapidly as it is formed. The absorption of this poisonous gas must be deleterious to the patient. It may cause headache, vertigo, nausea, and epigastric oppression.

Marsh gas is generated in the bowels in considerable quantity after living on a diet consisting chiefly of proteins, or after consumption of peas or beans, and in the decomposition of cellulose. Its coefficient of absorption is very low; hence the discomfort arising from the presence of this gas.

Methyl mercaptan (CH_3SH) occurs among the gases resulting from the decomposition of proteins by bacteria in the intestines, and also after consumption of cabbage, asparagus, etc. It is an evil-smelling gas, and Bunge remarks that as most of the poisonous products of protein decomposition are without smell, the odour of this gas gives warning of their presence.

The diet largely influences the degree of flatulence, the kind of gases, and the discomfort arising from them The composition of gastric flatus is given above. Ruge found the composition of flatus from the intestines varied with different diets; thus: Patients who

Composition of Intestinal Flatus from Various Diets.

Gases.	Milk Diet.	Leguminous Milk Diet, Four Days.	Milk Diet, Three Days.
	Per Cent.	Per Cent.	Per Cent.
Nitrogen	36·71	18·96	64·41
Hydrogen	54·23	4·03	0·69
Marsh gas	—	55·94	26·45
Carbonic acid	9·06	21·05	8·45
Sulphuretted hydrogen	—	trace	—

suffer from flatulence should avoid the articles of food liable to undergo fermentation. *Milk* is especially injurious; many persons experience discomfort, fulness, and flatulence after it. Its lactose is decomposed into lactic acid, and the latter into butyric acid, with the evolution of hydrogen and CO_2. *Carbohydrate* foods

are also very likely to give rise to discomfort. Dextrose, the product of digestion of various carbohydrates, is split into lactic and butyric acids, hydrogen, and CO_2. The foods most likely to give rise to flatulence are potatoes, bread, cereals, and the legumes, because a large quantity of them is carried down to the lower part of the small intestines, where the alkalinity favours bacterial action. Rice, sago, tapioca, and arrowroot do not cause so much flatulence, because they are more readily digested, and are absorbed to a large extent in the upper part of the bowels. Rice is almost entirely absorbed in the upper bowel. It is therefore better to recommend carbohydrates in these forms; they may be taken with stewed fruits, because the organic acids conveyed into the bowels with them tend to check butyric fermentation.

Cabbage and all other vegetables containing fibrous tissues or much cellulose should be avoided, because they give rise to pain and flatulence from the decomposition of cellulose into hydrogen and marsh gas.

Flatulence often arises from the air swallowed with food, eating the food too quickly, defective mastication, and washing down the food with large draughts of liquids. In such cases a feeling of distension occurs before the meal is over and gives rise to eructations. Careful and slow mastication and avoiding drink during the meal are indications which should be followed. The fermentation of carbohydrates in the stomach occurs in obesity, but it is more likely to occcur in chronic gastric catarrh, dilatation, and motor inefficiency. The free HCl of gastric juice causes an evolution of CO_2 even in healthy subjects by neutralizing the carbonates in saliva and food; this may occur also in hyperacidity, for in such persons Roberts found the alkalinity of saliva was abnormal, and frequently equal to 0·04 per cent. of HCl. Flatulence may be due to the regurgitation of gas from the duodenum and the small intestines; it may also arise from the diffusion of CO_2 from the blood of the gastric veins into the stomach. This is probably the cause of the otherwise inexplicable attacks of "wind" which occur in many persons otherwise healthy. In these cases the evolution of gas is too rapid and too voluminous for it to arise by fermentation, and usually there is no reason to suspect such fermentation. It is a trouble which attacks healthy and hard-working women, especially those who are subject to nervous excitement or great emotion. It has been suggested that the actual cause is some disturbance of the expiratory function. The treatment of such cases is the prescription of light food, especially light suppers, reduction of carbohydrates, and avoidance of overwork and worry.

Atony and Dilatation of the Stomach.

The indigestion results in a loss of tone, atony, or myasthenia, and sometimes dilatation of the stomach. Atony, frequently termed "gastric insufficiency," means that the stomach is unable to

discharge its contents into the duodenum in normal time. It is often associated with diminished gastric secretion (both pepsin and acid), but this is not constant. It is a sequel of long-continued dyspepsia; but it may result from sedentary occupation, overwork, acute illness, repeated losses of blood, prolonged suppuration, etc. Non-obstructive dilatation or primary gastrectasis is the result of atony, due to gastric irritation, insufficiency, or catarrh, with the attendant fermentation. Obstructive dilatation, or secondary gastrectasis, is not the result of primary weakness of the muscular walls; the muscles have more work than they can accomplish. Up to a certain point the stomach is assisted by hypertrophy, but this is followed by diminished power and increasing dilatation. The influence of dilatation on the nutrition of the body is shown in the increasing emaciation and weakness observed in every serious case.

Treatment.—In **atony** of the stomach, or gastric insufficiency, the underlying condition of deficient vital power and innervation of the stomach must be attacked. The remedies which will remove debility will assist in improving the contractile power of the stomach, will encourage motor activity, promote absorption, and increase the secretion and quality of gastric juice.

The indications are—(1) To render the digestion easy by reducing the quantity of food to the capacity of the stomach and selecting those articles suitable for the condition; (2) to excite metabolism and nutrition by exercise of the mind and body; (3) to remove the proximate cause of the disease.

The food is important. Any necessary change should be gradually produced; but there should be an immediate prohibition of many of the indigestible articles of diet. The condition is best met by a **dry diet**, consisting chiefly of animal substances and of small bulk. If the appetite flags, reasonable abstinence would be better than pampering the palate with dainty fare. When the appetite is good, the patient should stop short of satiety; it is better to eat too little than too much. There should be only three meals a day, consisting chiefly of proteins—*e.g.*:

Breakfast, 8 *a.m.*—Fish (sole, plaice, whiting, haddock, turbot, brill, weak-fish), with a little lemon-juice; one or two eggs, poached or boiled lightly; a small amount of crisp dry toast or stale bread; and a cupful of coffee, with cream and one piece of sugar.

Midday Meal, 2 *p.m.*—*No Meat*. Boiled macaroni with a trace of grated Parmesan cheese, or boiled rice with tomato; purée of cabbage, savoy, or potato, with gravy or extract of meat; boiled spinach, vegetable marrow (squash), string or snap kidney beans; any milk pudding which has been cooked slowly (four or five hours), jellies or creams made with gelatin, or fruit jelly, and cooked apples, plums, prunes, and raw fruits rubbed through a sieve (raspberries, strawberries, and blackberries or currants). At end of the meal 4 or 5 ounces of water, diluted spirit, Burgundy, or Bordeaux.

Evening Meal, 8 *p.m.*—Soup, about 3 ounces; fish (same as at breakfast); tender lean beef or mutton, poultry, venison, pheasant, partridge, or other game (except hare); 1 ounce of purée of potato, or boiled rice, or toast, or stale bread. *No pudding or dessert;* at end of meal two glasses of wine or

1 ounce of whisky in 4 ounces of water. The food has a heat value of 2,150 calories, and contains:

DAILY FOOD FOR CASE OF ATONY OF STOMACH.

Materials.	Ounces.	Protein.	Fat.	Carbo-hydrates.	Alcohol.
		Grammes.	Grammes.	Grammes.	Grammes.
Fish, reckoned as haddock	14	87·0	9·2	—	—
Meat, reckoned as mutton	14	100·0	40·0	—	—
Vegetables, reckoned as spinach	3½	3·1	0·5	3·5	—
Potato	1½	1·0	0·1	11·0	—
Bread	3½	8·0	0·5	50·0	—
Rice	1½	2·5	0·4	42·0	—
Milk	7	8.0	8·0	9·0	—
Sugar	1	—	—	27·0	—
Bordeaux	5	—	—	—	21
Whisky	1	—	—	—	14
Total	—	209·6	58·7	142·5	35

The idea is to give two meals mainly protein, and most of the carbohydrate at the midday meal. The use of diastatic substances is much in favour among a certain section of the profession; they recommend takadiastase or some form of malt extract when a large quantity of carbohydrate food is taken—*e.g.*:

WEGELE'S DIET FOR ATONY OF THE STOMACH.

Morning.—Dry toast, 1 ounce, a cupful of cooca made of leguminose cocoa, and 2 ounces of cream.

Forenoon.—An egg (poached or soft-boiled) and 1 ounce of toast.

Midday.—Scraped meat, 3½ ounces; mashed potato, 7 ounces; toast, 1 ounce; followed by 1 ounce of extract of malt.

Afternoon.—A cupful of cocoa, with 2 ounces of cream.

Evening.—Tapioca, cooked to a pulp, 10 ounces; followed by ¾ ounce of extract of malt; 10 p.m.: a tumblerful of milk, with dessert-spoonful of cognac brandy.

Forbidden Articles.—All those in the list under Indigestion. The total liquids should not exceed 1½ to 2 pints, and for a few weeks might usefully be reduced to ¾ pint a day. Sweet and acid drinks are injurious. Excess of milk puddings and custards may do harm by their carbohydrates. All fish containing more than 2 per cent. fat is injurious (see list, pp. 11 and 229); other fatty foods the same. All boiled vegetables, except those which are very tender, must not be eaten unless they are rubbed through a sieve (purée); the same rule applies to fruit containing seeds and skins which cannot be removed. Nuts, dried peas, and beans, mushrooms, truffles, morels, must be avoided.

Alcohol.—Malt liquors and sweet wines are injurious; but one or two glassfuls of *dry* wine is beneficial. " Gastric insufficiency is perhaps the only stomach condition in which alcohol may be given

with benefit."[1] Port is inadmissible because of its acidity; but Bordeaux or other good claret or hermitage is not usually deleterious. Tea, coffee, and cocoa should be taken in great moderation, and used chiefly for flavouring.

More or less **permanent atony or gastric insufficiency** occurs in malignant disease of various organs, tuberculosis, prolonged suppuration, and amyloid disease, and from local causes, such as atrophy of the secretory glands and cancer of the stomach. There are degrees of insufficiency. When it is not very severe, the diet should be the same as in the curable forms. Severe cases tax the ingenuity of the physician and nurse; in fact, there are few patients more troublesome to feed than those in a late stage of cancer (*e.g.*, uterine, ovarian, or mammary). The gastric insufficiency is progressive. Very little food can be taken or digested; the total is not enough to prevent emaciation. The patients speedily tire of any article, and changes have to be found every day or two. Milk foods, junket, milk jelly, custard, milk soup, peptonized foods, Benger's food, Ovaltine, Mellin's food, Savory and Moore's, Valentine's meat juice, Brand's essence, beef tea, meat juice, dried milk powders, meat extracts and powders, and all other light and easily-digested foods may be used in succession.

Atonic or Simple Dilatation.—The indications are—(1) To distend the stomach as little as possible, (2) promote evacuation of its contents through the pylorus, (3) keep down fermentation, (4) and improve the tone of the organism. These indications are fulfilled by the treatment and dietary detailed for atony. The food should be good and nutritious. The patient should lie down for at least half an hour after each meal. The cure is more difficult when motor insufficiency and hypochlorhydria are well marked. In such cases the treatment should be begun by confining the patient to bed for a time and giving a restricted diet, containing very little carbohydrates, and consisting of about a pint of milk with Plasmon, Sanatogen, or other casein preparation, or dried milk added to it, in three or four doses at intervals of four or five hours; intermediate meals should consist of raw eggs, beef juice, pounded chicken, or fish or scraped beef, and a small amount of stale bread cut into thin slices and thoroughly torrefied. The total dietary should not yield less than 1,600 calories, the smallest amount required for a person at absolute rest. After ten to fourteen days the patient may be allowed to rise for a few hours daily and take light exercise, but he should continue to lie down for an hour after meals. The dietary may then be improved so as to yield 2,000 calories by giving poached or boiled eggs, minced or scraped meat, chicken panada, or soufflé, sweetbread, sole, plaice, whiting, raw oysters, potato purée, spinach, vegetable marrow, occasionally cauliflower, dry toast, zwiebach, arrowroot, custard, junket, and cocoa, or about ¼ pint of *plain* water or Salutaris after meals.

The convalescent stage requires a dietary in which the fluid does

1 Martin, "Diseases of the Stomach," p. 316.

not exceed 30 to 40 ounces. If hypochlorhydria exists, the carbohydrates must predominate in the dietary, and should be of an easily digested kind, and the food should be given warm. If, on the other hand, there is hyperchlorhydria, fat, especially butter and cream, are useful, and proteins must predominate. Lavage is a useful expedient, but it is not necessary in every case. Massage, douching, and electrical treatment are also beneficial. Change of air to an upland bracing district, such as Buxton, Harrogate, Braemar, Clifton, Malvern, or Tunbridge, in Great Britain, or to various seaside resorts (but not to the south or south-west coasts) of England during the summer or autumn is good treatment. Switzerland, the Riviera, Genoa, and Naples are also suitable resorts.

Secondary, or Obstructive Dilatation.—In primary, or atonic, dilatation of the stomach the object of dietetics is to insure the emptying of the stomach as quickly as possible; we must be satisfied with intestinal digestion. In the secondary, or obstructive, form the main object is to secure the absorption of foods from the stomach itself. In these cases there is not usually any deficiency of the muscular strength; on the contrary, there may be hypertrophy of the muscular bands and increased power; but owing to the obstruction, there is a relative motor insufficiency.

In such cases it is useless to give bread, potatoes, sweet potatoes, oatmeal, biscuits, rusks, and vegetables; they cannot be digested in the stomach and their passage into the bowels is hindered. Their presence encourages fermentation, with its attendant heartburn, flatulence, acidity, belching, and regurgitation or vomiting; therefore they should be omitted from the dietary. The proper treatment consists in giving easily digested proteins and as little undigested carbohydrate as possible.

Milk may be given alone or with citrate of soda to prevent the formation of curd; it may be peptonized or pancreatized, and enriched by the addition of ½ ounce of lactose or extract of malt to each ½ pint of milk. Both these carbohydrates are valuable; but lactose has an advantage over the maltose in not being fermented by ordinary yeasts. The rest of the food may consist of raw eggs, scrambled eggs, scraped or minced meat, pounded chicken, soft fish, oysters, meat powders, meat extracts, and casein preparations. We have to provide more protein to make up for the deficiency of carbohydrate, remembering that many proteins contain a carbohydrate complex which will be utilized by the organism. At the same time, we must watch the nitrogenous excretion, taking care that the urea output is proportionate to the intake of proteins. The heat value of the food prescribed must also be taken into account, and the number of calories should not be much less than the same person requires during a slack time in a state of health; 3 pints of milk, two eggs, 10½ ounces of meat, chicken, and fish, and 1 ounce of milk sugar will yield 2,000 to 2,200 calories. The question of peptonizing the food will arise; it has been shown that artificial digestion by pepsin or pancreatin is not quite the

same as normal digestion. Voit, Cahn, and others have shown that artificially digested foods are not absorbed without further change; and others, again, have shown that very little peptone is absorbed from the stomach. The best thing to do is to reduce all food to a pulp by a mincing machine, to remove all stringy or fibrous portions by passing it through a sieve, and thus assist its passage through the pylorus. If, however, the obstruction becomes so great as to necessitate the predigestion of foods, we can have recourse to peptonized and pancreatized milk, panopepton, Liebig's peptone, Leube's soluble meat, Valentine's meat juice, somatose, Mosquera's beef meal, Kemmerich's peptone, Denaeyer's peptone, Carnrich's peptonoid, Darby's fluid meat, etc. The predigestion of carbohydrates is unnecessary if the proper kinds are used—viz., malt extract, invert sugar and lactose, and milk in such a condition that it is easily propelled into the duodenum; but all such dietaries may be useless in bad cases, nutrient enemata must be resorted to, and the question of gastro-enterostomy or some other suitable operation may be essential to prolong the life of the patient.

Various other points require attention in both forms of dilatation. **Rest** after food is essential. When the patient is in bed, it is of importance to attend to his **posture.** The stomach may become more distended by the mere weight of its contents. He should lie upon the right side to facilitate the passage of food into the duodenum. Ewart recommends the foot of the bed to be elevated, the level of the greater curvature of the stomach to be thereby raised, and the distance to the pylorus lessened. The proper application of **massage** to the abdomen before breakfast or two or three hours after a meal, when there are no counter-indications, would assist the stomach to discharge its contents. It is recommended by Boas, Ewald, Riegil, Sidney Martin, and other authorities, but Rossenheim and Ziemssen are against it. General massage is useful.

Lavage of the stomach is generally recommended, but it does not meet with everybody's approval. For instance, Saundby says the stomach-tube should not be used except when surgical aid is refused; then the patient may be taught to wash out his stomach each night to remove food residues. Most authorities, however, consider it to be a valuable proceeding. It should not be done too often, perhaps twice or thrice a week. It tends to remove motor insufficiency. The vicus may be washed out with alkaline spa waters, solution of carbonate of soda, water containing 1 per cent. of calcined magnesia, or a ½ per cent. solution of tannin. The latter is recommended by Hemmeter. Pain and spasm, which sometimes occur, are prevented by pouring into the stomach 2 or 3 ounces of olive-oil after lavage. An emetic (20 to 30 grains of ipecacuanha) is valuable for patients who refuse lavage; it empties the stomach, causes contraction, and squeezes morbid secretions out of the glands. The stomach may be too feeble to respond to such stimulation; in such cases lavage must be adopted. In most cases a

beneficial effect soon follows its use When lavage fails, the intragastric spray may be used. Galvanism is also useful; the continuous current should be used, the negative electrode to the nape of the neck, and the positive to the epigastrium. The electrodes should be covered by flannel.

The general health must receive attention. The patient should be ordered rest from business or domestic worry, change of air in the moorlands or mountains. Irregular hours and meals must be avoided. The patient should go to bed early and rise early; the bedroom must be well ventilated. The body must be kept clean, but frequent hot baths are injurious; shower-baths are beneficial to some and sea-baths to others. Exercise is important; it should be taken about three hours after a meal, or before a meal. Walking and riding short of fatigue, gymnastics, tennis, croquet, golf, etc., are useful.

Gastroptosis causes stagnation of the contents of the stomach, with a sensation of weight, fulness, oppression, nausea, or vomiting. It is associated with functional disorders of the stomach and neurasthenia. The neurasthenia should be treated by the "rest cure." Many of the symptoms disappear when the recumbent posture is assumed. The diet, at first, should be similar to that for dilated stomach: minced meat, chicken, or fish; purée of vegetables; dry toast, zwiebach; butter, honey. The food should be eaten without drinking; mastication must be carefully performed; liquids should be taken between meals. A diet for overfeeding should be gradually built up to improve nutrition and cause the accumulation of a few pounds of fat in the abdomen. After the rest cure, the diet must be that required for the associated conditions—atony, hyperacidity, etc. A belt should be worn; the patient should be taught to sit upright and to breathe properly. Surgical treatment is sometimes necessary.

Catarrh of the Stomach.

Acute Gastric Catarrh.—It occasionally follows catarrh of the respiratory organs, influenza, diphtheria, fevers, septicæmia, but it is more often due to local irritation by taking an excess of certain foods, tinned foods, substances which are fermented or decomposed, acid wines, spirits, mineral acids, alkalies, and other irritant poisons.

1. *Acute Phlegmonous Gastritis.*—The extreme irritability contra-indicates oral feeding; nevertheless, it is proper to give a little ice, ice-water, albumin-water, barley-water, and cream, Valentine's meat juice, Brand's essence of beef, and small quantities of demulcent liquids. Rectal feeding should be resorted to after twenty-four or thirty-six hours if mouth feeding cannot be borne. When the severity of the inflammation is subsided, the dietary for the subacute form may be adopted.

2. *Subacute Gastritis.*—The symptoms are milder, the prognosis favourable. The stomach must be rested. Ice, ice-water, barley-

water and cream, raw-meat juice, Valentine's or Brand's meat juices, may be given. The CO_2 in Perrier, Apollinaris, and other waters is sedative; the alkalies in Apollinaris, Ems, Vichy, or Vals waters neutralizes acidity, lessens the toughness of mucus, assists its evacuation, and moderates hyperæmia. Mucilaginous fluids check irritability (*e.g.*, decoction of inner bark of elm, tragacanth, or isinglass emulsions). When the irritation begins to subside, pain and vomiting to cease, we may begin to give equal parts of milk and barley-water, lime-water, or soda-water. If these are vomited, let 1 grain of sodium citrate or 3 grains of potassium bicarbonate be added to each ounce of milk. Some patients retain arrowroot and milk, Benger's food, or jelly, when they vomited other foods. The proper quantity to give is 1 ounce of fluid every half hour, 1 ounce of farinaceous food every three hours, and some Brand's essence, Valentine's meat juice, or jelly, at times between the other feeds.

As improvement occurs we may cautiously add chicken broth, veal broth, custard, junket, sago or tapioca pudding, rice-milk. The quantity must be small, but may be gradually increased. When these things are well tolerated, we should try a poached egg, then some sole, plaice, or whiting, and a spoonful of potato purée. Gradually add bread-and-butter, spinach, vegetable marrow, purée of cabbage, cauliflower, stewed prunes, baked apples, and cooked plums. These may be followed by chicken and tripe. The return to ordinary diet ought to be very gradual, otherwise the catarrh may become chronic. The future dietary must be that for dyspeptics, and the articles to be avoided are those detailed under that heading.

Chronic Gastric Catarrh (*Chronic Gastritis*) may follow acute or subacute gastritis, and any of the causes of indigestion and gastric irritation previously mentioned, by their persistence, may induce it. It may also be secondary to influenza, fevers, hyperæmia of the liver, diseases of the heart, lungs, or pleura. It occurs in persons of chronic ill-health, sedentary habits, or a phlegmatic disposition; it is favoured by cold, damp climates, and wet seasons. It is most common in middle life, but is also met with in elderly people and even at the period of puberty.

Treatment.—Most cases of primary gastric catarrh of the stomach are curable by careful and persistent treatment, and secondary catarrh often disappears after careful treatment of the stomach and other diseased organs. To this end all indigestible foods must be forbidden; also malt liquors, spirits, excess of tea, coffee, and tobacco. Careful attention must be given to the teeth; pyorrhœa alveolaris must be cured. The food must be eaten slowly and carefully masticated. The patient should rest a short time before meals and a longer time afterwards. His life must be carefully and well regulated. It should be free from worry; rest and tranquillity should prevail, but the mind and body must be regularly occupied in moderation. The indications may be classed as follows:

To—(1) select food of a kind and quality to suit the morbid condition and improve its nutrition; (2) excite the function of digestion by reasonable exercise adapted to the strength and condition of the patient; (3) encourage the harmonious action of the alimentary canal; (4) correct any morbid condition which predisposes to or aggravates the catarrh.

The diet is of paramount importance; but patients vary so much that no stereotyped prescription will suit them all. Everything depends on the ability of the stomach to digest and propel its contents into the intestines. The degrees of gastric catarrh vary from a slight diminution of the functions of the mucosa to absolute loss of secretion or atrophy of the gastric glands. An examination of the gastric contents after a test meal shows (1) diminution of HCl, or (2) absence of HCl, or (3) absence of the gastric ferments. The amount of free HCl is always diminished. If 0·2 per cent. of this acid is present we must exclude gastric catarrh and look for another disease. Much mucus in the vomit is a valuable indication of catarrh. The existence of gastric ferments should be ascertained.

The diet may include every food which the stomach is able to digest and propel into the duodenum in a proper time. In some cases the digestion of proteins is defective, while that of carbohydrates is perfect. In these cases some authorities order that animal foods should be abstained from and proteins given in a prepared or semi-digested form; but, although the gastric juice is deficient in quality or quantity, there are digestive secretions in the bowels. Moreover, the patient must have some protein, or the condition of the body will never improve. Fatty foods are more or less deleterious, because they check gastric secretion; but a moderate amount of cream and butter are usually allowed. Farinaceous, saccharine, mucilaginous, and gelatinous foods are usually digested well, but if the motor power of the stomach is defective, farinaceous foods may ferment and cause flatulence, organic acidity, eructation of flatus or fluids, or distension, and aggravate the evil we wish to remedy. Milk does not agree with all cases; but when the disease is due to alcoholism, we should persist in its use. If it is not borne well at first, let it be tried with citrate of soda, bicarbonate of potash, lime-water, barley-water, Perrier or Apollinaris water. If plain milk still disagrees, try the milk powders, casein preparations, peptonized milk, whey, or buttermilk. So strongly did Niemeyer approve of buttermilk for chronic gastritis that he wrote: "When the patient is hungry, let him eat buttermilk; when he is thirsty let him drink buttermilk." The advantages are that it contains very little fat and forms light flocculent curds in the stomach.

The dietary may be divided as follows:

1. *In mild cases* no limitation of food is necessary, providing it is of the right kind and quality. The foods and restrictions for ordinary indigestion are proper. The following may be useful to begin treatment:

Breakfast.—Eggs, lightly boiled or poached; fish of the lighter kinds; dry toast or rusk; cocoa made with milk, or milk-tea (China tea infused with boiled milk instead of water).

Lunch.—Mutton or lamb free from fat (inside of leg or underside of shoulder), mashed potato, milk pudding.

Tea.—A cup of China tea, thin slice of bread-and-butter, Marie biscuit, or sponge cake.

Dinner.—No soup; fish of a light kind; tender beef, mutton, lamb, fowl, pheasant, guinea-fowl, breast of turkey; potato purée, spinach, vegetable marrow (squash), cauliflower, seakale, fresh green peas, asparagus, spring cabbage, milk pudding, custard or junket with stewed fruit, jelly and cream, white bread, rusk, toast, or plain biscuit.

Things to be avoided.—In every case of gastric catarrh it is necessary to remove every particle of gristle and skin of fibrous material from meat, fowl, or fish; to avoid heating sauces and rich foods, such as articles cooked in fat and containing much fat—*e.g.*, pork, veal, high game, duck, goose, turkey (except the breast), fat meat, fried meat and fish, tinned meat and meat pastes. Fat ham, bacon, butter, and other fats ought to be forbidden because they check the secretion of gastric juice. Fish containing more than 2 per cent. of fat should not be ordered; others should be forbidden —*e.g.*, sardines—because of the small bones and scales. Salted or smoked meat and fish and all twice-cooked foods (entrées, etc.) are forbidden; also hot bread or pastry, brown bread, porridge, cakes and biscuits with seeds or fruit. All fruits containing seeds and skins which cannot be removed—*e.g.*, currants, gooseberries, cranberries, blackberries, bilberries, strawberries, grapes, and figs) should only be allowed after they are rubbed through a sieve. Nuts are taboo. Raw fruit can be allowed in moderation when the skin, strings, and seeds have been removed—*e.g.*, apples, pears, bananas, oranges, grapes, plums, and peaches. Raw vegetables of all sorts should be rejected; also pickles. Cooked fibrous vegetables, such as cabbage, swedes (*Ruta baga*), turnips, artichokes, sweet potatoes, carrots, cannot be allowed unless they are rubbed through a sieve and made into purée. Cheese, condiments, ices, etc., are forbidden.

2. *In cases of medium severity* the patient may have any food which has been passed through a sieve, besides soups, broths, purée of vegetables, consommé, meat powder, scraped meat, poached or soft-boiled eggs, light fish, tender lean meat or chicken. Stale bread, toast, rusk, zwiebach, biscuit (cracker), may all be taken if they are well and carefully masticated. Macaroni, vermicelli, sphaghetti; sponge cakes, Madeira cake; honey, golden syrup; fruit jelly, such as apple, damson, quince, or guava; apple sauce, apricot sauce; and other fruits (*vide supra*), after being passed through a sieve, are permissible. The supply of carbohydrates as a rule should not be restricted provided they do not include fibrous vegetables. The use of arrowroot, *tous les mois*, corn-starch, blancmange, and porridge should be prohibited, because they are swallowed without mastication and do not get mixed with saliva. Cream and butter are allowed in strict moderation; but fat meat and excess

of butter are forbidden. Spices and condiments are useful by stimulating the gastric secretion, and by their carminative and aromatic effects.

At the beginning of treatment such patients should have *a mixed solid and liquid diet.* Breakfast and supper should consist of boiled milk with stale bread, toast, rusks, or bread-and-butter. The midday meal of boiled fish, chicken, or scraped beef, with bread and butter. Fish should consist of sole, plaice, whiting, fresh haddock or turbot, boiled or steamed, freed from skin and bone, and pounded in a mortar; a little cream may be added. Chicken should be done in the same way. Beef is prepared thus: Three or four ounces of fillet or rump steak is lightly broiled with a little salt; it is then cut open and the red pulp scraped away from the fibrous tissue. The scrapings are eaten as sandwiches, being spread on thin bread-and-butter, and sprinkled with salt. Between the meals a glassful of boiled milk is to be taken. If the diet disagrees, more fluids must be given. If it agrees, a gradual advance should be made. Thus, at the midday meal some unpounded sole, plaice, whiting, or breast of chicken may be tried. A few days later, a piece of tender fillet steak, not too much broiled, may be allowed for a change, and some very thin rice pudding. Articles named above may each be tried in turn. A patient can subsist on such a diet and perform his duties without discomfort. It is very suitable for cases of gastric catarrh of two or four months' duration, and with little vomiting. The duration of such treatment is a matter of judgment; but additions must be gradually made until it attains the character of *a modified ordinary diet.* The rules for this are the same as for bad indigestion (*q.v.*). The addition of each article should be experimental. What is digestible for one person is indigestible for another. In most cases protein foods should preponderate, because fat and carbohydrate are little digested in the stomach, and throw a strain on the diseased organ. This diet should, then, consist of scraped beef or mutton, the inside of a chop or cutlet, a slice from the underside of a shoulder or inner-side of a leg of mutton; the breast or wing of boiled chicken, breast of pigeon; or boiled or steamed fish (sole, plaice, whiting, turbot, fresh haddock); lightly boiled or poached eggs; potatoes rubbed through a sieve, spinach, boiled lettuce, vegetable marrow (squash), cauliflower, kidney beans (string or snap), green peas, seakale, boiled onions; puddings of ground rice, sago, tapioca, arrowroot, baked flour and milk; white bread, toast, rusks, plain biscuits. A little butter and cream; a small amount of mustard, vanilla, or almond flavouring. China tea or peptonized cocoa may be allowed. A tablespoonful of whisky or brandy well diluted, or a glassful of well-matured claret, burgundy, or dry champagne, may be allowed with lunch and dinner.

3. *In severe cases,* where the patient complains that everything disagrees and vomiting occurs every day or two, *a liquid diet* is essential. This may consist of 3 or 4 pints of milk taken in tum-

blerful doses every two hours. It should be boiled or baked and cooled down to that temperature which is most agreeable to the patient, preferably lukewarm. Cold or hot milk is liable to cause pain. Occasionally some Bovril, Oxo, or other extract of meat, or some essence of coffee or peptonized cocoa may be put in some milk to alter the flavour. This diet may be continued for two to four weeks according to the effect; but the expenditure of the body should be kept in mind, the minimum when a person is resting being 1,600 calories (supplied by 4 pints of milk), and when absolutely quiet in bed, 1,400 calories (supplied by $3\frac{1}{2}$ pints of milk). If a person endeavours to follow his occupation on this diet, a reduction of weight must be expected. When relief from pain and sickness is secured, some improvement in the diet may be made, thus:

Breakfast.—Two ounces of stale bread is to be boiled in water and passed through a sieve or well beaten with a fork, and added to 1 pint of boiled milk. It may be varied by farinaceous food, such as Benger's, Savory and Moore's, or Neave's food.

Midday.—The same, with the white of two raw eggs mixed in the food, or an ounce of raw-meat juice or a cup of extract of meat may be taken before the food.

Evening Meal.—Bread and milk, 1 pint, at five or six o'clock.

Bedtime.—A tumblerful of milk.

The duration of the diet must vary with the effects. It ought to be continued so long as there is any bacterial fermentation or acidity in the stomach. When a sufficiently marked improvement is observed, the patient should be put on the mixed liquid and solid food. Benger's, Savory and Moore's, Neave's, or Allenbury's food, made with milk, should be first given; then arrowroot, *tous les mois*, tapioca, or sago pudding, and some well-dried toast, torrefied bread, or rusk, and butter. Cautiously add to the dietary: Poached eggs, steamed light fish, scraped meat sandwiches; chicken cream, panada, or soufflé, and other kinds of meat which have been passed through a sieve, with potato purée, vegetable purée, spinach, vegetable marrow, seakale, boiled lettuce; finally breast of chicken, pheasant, or guinea fowl, tender mutton, undercut of beef, and ordinary milk puddings.

Leube arranged the following progressive dietaries for such patients: (1) Clear soup or broth, **solution of meat,** milk, eggs—raw or lightly cooked—and plain or aerated water. (2) Add to the former boiled bread and milk, boiled chicken or pigeon, and calves' brains. (3) Add a small amount of bread and underdone beef-steak; the latter should be beaten, and the most tender portion scraped away and lightly cooked in butter. (4) Add roast chicken, partridge, pigeon, underdone beef (hot or cold) from a joint, macaroni, a small amount of cooked green vegetables, or salad or fruit, and a small amount of wine.

Leube's solution of meat is prepared as follows: Mince $2\frac{1}{4}$ pounds of lean meat, place it in a quart of water and 6 ounces of pure hydrochloric acid, and put it into a Papin's digester, and boil it for ten to fifteen hours. It should then be removed from the vessel, rubbed to a paste in a mortar, and

again boiled in the digester for twenty hours. The substance should now be neutralized by the gradual addition of bicarbonate of soda while constantly stirring it, and subsequently evaporated to a syrupy consistence. The solution should measure not less than 35 ounces; 1 fluid ounce represents an ounce of meat. It may be taken in tablespoonful or wineglassful doses; a small amount of salt may be added if necessary (but the soda and HCl produce salt), and the liquid may be warmed or mixed with an equal quantity of nearly boiling water. It is a useful food in gastric catarrh, hypochlorhydria, ulcer, or carcinoma of the stomach, etc.

Beverages for Chronic Gastric Catarrh.—Alcohol ought to be forbidden; but the subject cannot easily be dismissed. Many patients have been accustomed to it, and cannot, or will not, give it up; but they must be forbidden to take port, sherry, madeira, spirits, and malt liquors. They may be allowed a little good Bordeaux, Burgundy, or red Hungarian wine, although in severe cases it must be diluted with an alkaline water. *Hot liquids should be forbidden;* everything should be drunk only warm. A cupful of China tea, thin cocoa, or some whey, buttermilk, Salutaris, Perrier, Apollinaris, and other gaseous waters are the best beverages. Indian and Ceylon tea should be avoided. Vals, Vichy, Ems, Bilin, Cauterets, Plombières, Carlsbad, Friedrichschall, Condal, Rubinat, or Hunyadi János waters are all useful according to the effect desired; they should be taken warm.

Lavage of the stomach is a valuable aid to dietetic treatment. It is best done in the morning with a warm solution of sodium bicarbonate and chloride. If lavage is objected to, an emetic given to the patient twice a week is a useful procedure.

Moderate exercise is of extreme value in medium and mild cases; walking, golf, tennis, and riding may be used. Swedish exercises are good.

A change of climate is useful. A sea voyage, even when sickness occurs, is beneficial. Change from a warm moist climate to a drier and bracing atmosphere in some, and away from a bleak mountainous district to a warm, dry air for others. A season in Devonshire is good for some; but the drier air of Brighton, Bournemouth, Margate, Pau, Cannes, Nice, Pisa, Rome, Algiers, Egypt, for those with relaxed state of the system. Harrogate, Ilkley, Buxton, Matlock, Malvern, Clifton, the Scottish and Swiss resorts are for those with passive congestions, anæmia, neurasthenia, or other nervous affections.

The Treatment of Gastric and Duodenal Ulcer.

The "rest-cure" must be carried out with thoroughness; it is a *sine qua non* of successful treatment. Absolute physiological rest is essential. We must therefore insist upon confinement to bed for at least fourteen or twenty-one days, to give rest to the body and reduce the requirements of the system to the lowest quantity. If absolute rest is not obtained, a mild case may be relieved by dietetic treatment; but under such circumstances relapses fre-

quently occur; therefore, treatment without rest in bed is not recommended. Having secured this important item, the further indications are—(1) To avoid all foods which would physically or chemically irritate the ulcer; (2) to avoid such foods as cause a prolonged secretion of gastric juice, remain a long time in the stomach, or stimulate muscular contraction; (3) to permit such foods as are prescribed *in small quantities only*, and so avoid distension of the stomach. The more the stomach is contracted, the nearer the edges of the ulcer come together, the better will granulation and healing be favoured. The diet will depend upon the severity of the case.

In mild cases the treatment should be begun by giving an exclusive milk diet—say 2 ounces every hour and half from 6 a.m. to 10 p.m., or 24 ounces in twenty-four hours. This will yield about 500 calories. If it causes pain or vomiting, it should be peptonized, or given with 2 grains of citrate of soda in each ounce. It is allowable to use lime-water, Vichy water, or any other alkaline water with the object of preventing curds, the chief source of trouble; but the bulk of the food is increased without adding nutriment. On the second day of treatment give 3 ounces of milk every two hours. The amount of milk should now be increased ½ pint daily until 3 pints are taken. Each pint yields 410 calories, and the amount of heat given off by the body during absolute rest in bed is 1,400 or 1,500 calories; so that the nutriment derived from 3 pints of milk is not enough to prevent wasting of the body. After three or four days, therefore, it is advisable to add to the diet two raw eggs daily, and some dried milk powder or casein preparation (Plasmon or Sanatogen) may be added to the milk. Benger's food may be used, and once a day about an ounce of dry breadcrumbs may be well soaked in boiling water, strained, beaten to a pulp, and mixed with 3 ounces of milk. Some raw-meat juice, calf's-foot jelly, Brand's essence, etc., may be given. An exclusive milk diet is a semi-starvation diet. The minimum required to supply the heat given off during absolute rest in bed is 4 pints. This would mean 16 teacupfuls a day. It is scarcely possible to maintain this standard, although there are many patients who can take 3 pints of milk a day, besides other foods. But meat extracts and essences of all kinds should strictly be avoided, because they tend to stimulate gastric secretion and exaggerate the condition of hyperacidity.

After two or three weeks of milk diet we may gradually increase the consistence and calorie value of the food. For this purpose we should, first of all, use dextrinized cereal foods, such as a fine biscuit powder (Allenbury's, Neave's, Ridge's, or Savory and Moore's food), *baked* fine oatmeal, arrowroot, *tous les mois*. If these are tolerated, we should gradually increase the solidity of the food by adding baked custard, junket, peptonized milk gruel, long-boiled fine oatmeal gruel, and scraped meat, chicken soufflé, or panada. After a week or ten days of such dietary, an experi-

ment may be made with a small quantity of light fish—*e.g.*, sole, plaice, whiting, or fresh haddock—mashed potato, and stale bread (free from crust). If no recurrence of the symptoms occurs, some stale bread-and-butter, Madeira and sponge cake, or Marie biscuits, may be allowed with a cup of tea. Thence onward a gradual return to ordinary diet should be made, care being taken to avoid all foods which are indigestible, or would unduly tax the at present weak organ.

In severe cases of ulcer, with pain, vomiting, and hæmorrhage, most authorities agree that nothing should be allowed by the mouth for about a week. As a general rule pain ceases when no food is put into the stomach to irritate the ulcer. This fact serves to distinguish an ulcer from a neurotic stomach. Nervous gastralgia or cardialgia often simulates an ulcer of the stomach; but in these cases the freedom from pain only lasts while the novelty of the treatment lasts. All mouth-feeding, therefore, should be stopped, and rectal feeding adopted. Care must be exercised in the performance of rectal feeding. The meal should consist of not more than 5 or 6 fluid ounces. It may be administered through a No. 12 rubber catheter, to which is joined a piece of rubber tube and a glass funnel. The patient may lie on her back or side, or in the knee-elbow position (the latter is impossible when the patient is very ill) ; the funnel should be held about 2 feet above the patient's hips, the fluid poured into it, and allowed to enter the colon by gravitation. Some practitioners use a glass rectal tube, but the catheter is preferred by most people, and it is believed that it can be insinuated farther up the rectum, and even into the sigmoid flexure. Ewart[1] prescribes *continuous* rectal alimentation, as follows: The catheter, previously attached to 2 or 3 feet of rubber tube, is inserted into the rectum as far as it will go without doubling, and allowed to remain in all day. At the opposite end of the rubber tube is fixed the body of a 5-ounce glass syringe. A clip is put upon the tube, and the flow through it so regulated that 5 ounces of fluid will pass through it in two hours. Ewart prescribes the following mixture: To 1 pint of milk add two raw eggs, beaten up, two teaspoonfuls of extract of malt, and a little brandy.

The idea of rectal feeding originally was to give the patient enough nutriment to supply the waste of the tissues during the starvation period, and a little over to help the healing process. It is now well known that it is impossible to maintain the body in equilibrium by rectal feeding, that, in fact, only about one-eighth the amount of nutriment required by the body during absolute rest is absorbed from the lower bowel, and that the patient remains during this period in a state of subnutrition—in other words, the body wastes because it is living upon its own tissues. Griffiths mentions two guides as to the adequacy of the nutrition afforded in this way: When the patient is amply fed, the tongue is moist and the breath is sweet; but when the patient is starving, or the nutri-

[1] *Brit. Med. Jour.*, 1903, ii. (Report of discussion at B.M.A. meeting).

tion very inadequate, the breath is tainted or offensive, there is considerable thirst, and the tongue is dry. Some authorities, observing the small amount of nutriment absorbed, question the necessity for rectal feeding during the time when nothing is allowed by the mouth; they say nutrient enemata satisfy the mind, but not the body. This statement is true. But rectal feeding is better than absolute starvation, however inadequate it may be. Experience has shown that it cannot be safely continued alone for more than ten days; the absorption of nutriment is too scanty, and the risks from starvation quite as serious as those from stomach feeding.

It is, however, a fact established by experience that when rectal feeding is properly carried out, the patient is usually free from pain, hunger, vomiting, and thirst, after a few days of treatment. Various troubles are liable to arise during rectal feeding. The mucous membrane becomes very irritable; it is therefore advisable to wash out the bowel once a day with a pint or so of warm boracic lotion or other mild antiseptic, to check putrefaction and subdue irritability. The addition of a few drops of laudanum to alternate "feeds" will assist in reducing irritation. A few grains of common salt also helps to keep down the sensibility, and assists in the absorption of egg-albumin; the addition of bicarbonate of sodium checks undue acidity. Mumps sometimes occurs, and requires ordinary treatment, but it may go on to suppuration. This may be prevented by the use of a mouth-wash.

The question of allowing fluids by the mouth during the first few days of the treatment has also to be considered. As a general rule *nothing whatever should be allowed by the mouth for four or five days.* If medicines are necessary, they should be injected subcutaneously. Some authorities allow small pieces of ice, iced water, Vals, Vichy, or other alkaline waters, to quench the thirst. King allows a teaspoonful of plain water every quarter of an hour, amounting to 15 ounces in twenty-four hours, on the supposition that the quantity is too small to irritate the ulcer, and is very soon absorbed, or passes through the pylorus. Large quantities certainly do harm. If we act on the principle of giving absolute rest to the stomach, even the small amount recommended by King should be forbidden; it may excite gastric secretion or peristaltic action. Thirst subsides considerably after one day, or it can be checked by frequently washing the mouth with boracic lotion. The injection of 10 to 20 ounces of water into the bowel immediately after the daily "wash-out" quenches thirst, and satisfies the demands of the system as far as water is concerned. It is held by many authorities that this is the chief benefit derived from rectal feeding. The destruction of tissue proteins which occurs during starvation results in the production of water; the amount originating from the oxidation of food under normal feeding is 10 or 12 ounces a day, and it is considered that this is not reduced when the body is living on itself.

After four or five days of absolute rest of the stomach, the patient

may be given as a test two or three teaspoonfuls of milk and barley-water, milk and citrate of soda, or peptonized milk. If these cause neither pain nor sickness, the quantity may be increased the next day to 1 ounce every two hours, and continually increased by ½ pint daily for three or four days. We may now add some dried milk or casein preparation to the milk, and give somatose, nutrose, eucasin, peptones, or Leube's soluble meat. After this we should gradually increase the consistence and quantity of the food, and diminish the number of rectal feeds.

If the first meal by the mouth causes pain, we must desist for a few days longer, and rely upon rectal feeding, if necessary, up to the fifteenth day. It is impossible to maintain nutritional equilibrium all that time; the patient persistently loses weight and a considerable amount of muscle and fat. This loss is soon retrieved on returning to gastric feeding, if the absorption is normal. As soon as possible, after mouth feeding is properly established, we may begin to treat the ulcer in the same way as in a mild case, the food consisting of milk, junket, custard, raw eggs, jelly, stale breadcrumbs soaked in boiling water and beaten to a pulp, arrowroot, jelly, baked fine oatmeal, biscuit powder, and raw-meat juice; later on, scraped meat, chicken panada, light fish, and other foods suitable for treatment of the less severe cases of ulcer, may be given. The following is an outline of the treatment adopted by myself in most hæmorrhagic cases:

First to Fourth Day.—Nothing to be given by the mouth. Feed by the bowel every six hours with the following "feeds" alternately: (*a*) Raw egg, 5 ounces of peptonized milk, ¼ teaspoonful of salt, 1 teaspoonful of brandy, twice a day. (*b*) Milk, 6 ounces; extract of malt, 3 teaspoonfuls; laudanum, 15 drops, twice a day. Allow the malt ten minutes to act on the milk before it is injected. Wash out the rectum once a day with boracic lotion. Inject once a day 1 pint of water and salt, after washing out the rectum. The mouth to be washed out very frequently with boracic lotion.

Fifth Day.—Give by the mouth 1 ounce of peptonized milk every one and a half hours, and ½ ounce of raw-meat juice, with the same amount of port wine twice daily. Continue rectal feeding, washing out the bowels and mouth, as before.

Sixth Day.—Give 2 ounces of peptonized milk every two hours, one raw egg in milk, raw-meat juice, and rectal feeds as before.

Seventh Day.—Milk, 27 ounces, in doses of 3 ounces every two hours, two raw eggs in milk, 1 ounce of beef juice, and 1 ounce of port wine; rectal feeds as before.

Eighth and Ninth Days.—Milk, 35 ounces: 4 ounces every two hours; two raw eggs in milk; 1 ounce of beef juice; and 1 ounce of wine daily. Benger's food, 1 pint; a small cupful of tea. *Two rectal feeds daily.*

Tenth Day.—Milk, 2 pints; Benger's food, 1 pint; two raw eggs; beef juice and wine; Marie biscuits; tea.

Eleventh and Twelfth Days.—Feed every two hours. Milk, 2¼ pints; Benger's food, 1 pint; two raw eggs; fish (*plaice or sole*), 2 ounces; mashed potato (one tablespoonful); butter with potato; thin bread-and-butter (no crust); Marie biscuits; sponge cake; tea.

Thirteenth Day.—Milk, 2½ pints; chicken panada instead of fish; other foods as on twelfth day.

Fourteenth Day.—Milk, 2¾ pints; chicken or fish cream; other foods as before.

Fifteenth to Thirtieth Days.—Milk, 2½ to 3 pints daily; Benger's food twice a day; two eggs (raw, lightly boiled, or poached); fish (sole, plaice, or whiting); breast of chicken; tender underdone meat or scraped meat; mashed potato and butter; spinach; soup with lentil flour; bread without crust, butter, cream, sugar, tea, or coffee; Marie biscuit, sponge cake, Madeira cake (without fruit); stewed rhubarb, apple sauce, custard, junket, sago or tapioca pudding; orange juice, grapes freed from skin and seeds; jelly, fruit jelly.

Under proper care, an ulcer of the stomach usually heals in about three weeks. But the after-treatment of the patient is important. A careful regimen should be enforced, particular attention being given to the diet, the avoidance of dyspepsia, the correction of constipation, chlorosis, anæmia, and other irregularities.

The treatment indicated above ought to be carried out whenever it is possible. Experience has shown it to be the safest and surest mode, and the one most likely to produce a permanent cure. If a good result is not obtained, it is probable there are complications, such as perigastric adhesions, burrowing of the ulcer, induration and thickening of the edges of the ulcer, or perhaps stenosis of the pylorus. In these cases relief will follow rest of the stomach, the hyperæmia or catarrh will abate, but permanent benefit cannot be anticipated; an operation may be necessary. The indications for operative interference were classified by Von Leube as follows: (1) When gastric bleeding continues, or occurs repeatedly, and resists medical treatment; (2) when medical treatment fails to relieve pain, and persistent vomiting with inanition occurs; (3) in perigastritis, or abscess associated with the ulcer—*e.g.*, subdiaphragmatic or perirenal abscess; (4) when there is perforation of the ulcer.

The opinions of a few eminent physicians is appended. Ewald of Berlin says that gastric ulcer is one of the most satisfactory diseases to treat if the ulcer be not too old and there are no cicatricial contractions or adhesions to surrounding parts. He treats all cases suspected to be ulcer of the stomach by absolute rest in bed, abstention from mouth feeding for five or six days, and rectal feeding. He quenches thirst by small pellets of ice, hunger by a few drops of cocaine, and severe gastric pain by a small injection of morphine into the skin of the epigastrium. After this period he allows a test-meal consisting of a few spoonfuls of thin oatmeal, wheat-meal gruel, somatose, or nutrose. If the pain returns, he goes back to rectal feeding entirely. If there is no pain after the meal, he permits more food to be given the next day; and in three or four days adds any of the easily digested foods, in a semiliquid form. The amount and consistence of the gastric meals is increased daily, and the rectal feeding is gradually dropped.

Sir Lauder Brunton[1] begins the treatment of gastric ulcer by giving, in addition to nutrient enemata, a tablespoonful of milk and lime-water every two hours, gradually increasing the amount if the patient can take it without causing pain; if it causes pain,

[1] *Brit. Med. Jour.*, 1902, i. 497.

the quantity is diminished. After a few days, he gives custard; if this is borne without pain, he goes on to pounded fish, chicken, or meat. A nice liquid food or "cream" can be made of these—*e.g.*, take the breast of a chicken, cut it into thin slices, pound it in a mortar with a little chicken broth or beef-tea until it is a paste, and add a little more broth until it is of the consistence of milk or cream. Patients drink this liquid who will not take chicken-paste or panada. Brunton says avoid irritating the stomach by anything that will harm it chemically or mechanically. In the after-treatment avoid pepper, cayenne, vinegar, pickles, strawberries, raspberries, raisins, currants, and other fruit containing seeds, all kinds of nuts, all stones and bones, skins of fruit, skin or gristle of meat, fish-bones, spiculæ of bones, and vegetables containing cellulose.

Fleiner[1] confines the patient to bed for six weeks, stops all feeding by the mouth, *if the condition of the patient will permit it*, especially after hæmatemesis, and resorts to rectal feeding. He allows the patient to suck bits of ice, and the mouth to be washed out frequently by a plain or aerated water. After a few days, guided by the state of the pulse and subjective feelings of the patient, he begins to give nourishment by the mouth. He permits only milk at first, and not more than a tumblerful (250 c.c.) for a meal. If there is a necessity for more food, the milk is to be mixed with boiled arrowroot or maizena, or ground rice, the yolk of one or two eggs, and some cream. Later on he gives ¼ pint of Vichy-water before breakfast, to wash out the stomach, and increases the diet by adding boiled groats for breakfast, and, during the day, thick soups, milk jelly, and meat jelly. After four weeks he experiments with meat in the following order: Chicken, fish, pigeon, partridge, and tender veal; but red meats are not allowed until after six weeks. From this time onward the diet is gradually increased, care being taken to avoid crusts of bread, skin, gristle and tendon of meat or fowl, seeds of fruit, much salt, also pepper, mustard, or other spices, and alcohol. The patient is allowed to get up for a short time daily after six weeks, increasing the time day by day, but must continue to lie down after meals for several months.

Barrs of Leeds[2] says the most essential part of medical treatment is complete and prolonged rest in bed; without it, all other means fail to cure. He never orders rectal feeding nor a milk diet for gastric ulcer. He allows small meals of meat and stale bread, with plenty of water. The small bulk is of more importance than the kind of food. If it causes pain, he rests the stomach. Only when vomiting prevents the consumption of food does he prescribe rectal injections of glucose and water or normal saline solution. If there has been hæmatemesis, he allows no food for three or four days, excepting 3 or 4 ounces of water at a time to relieve thirst. Patients suffering from recent hæmatemesis are never hungry, and they require no food. Three or four days after the cessation of bleeding he prescribes meat, eggs, and stale bread, if there is appetite

[1] *Münch. Med. Woch.*, 1902, 22-24. [2] *Brit. Med. Jour.*, 1908, i. 390.

for them. No patient is allowed to leave her bed until ten days after she has been able to take ordinary mixed solid food, not only without pain, but actually with enjoyment.

Lenhartz, dissatisfied with rectal feeding, also tried the effect of food having a higher nutritive value and greater solidity than that usually prescribed, and was satisfied, not only of its safety, but that it was more suitable for the condition of hyperchlorhydria or the anæmic and enfeebled state of the patient At the Congress for Internal Medicine, 1901, he gave an account of his treatment. The items are given in the table:

LENHARTZ'S DIETARY FOR GASTRIC ULCER.

Days.	Eggs.	Milk.	Sugar.	Raw Meat.	Rice-Milk.	Zwiebach.	Raw Ham.	Butter.	Calories.
	Number.	C.C.	Grms.	Grms.	Grms.	Pieces.[1]	Grms.	Grms.	
1	2	200	—	—	—	—	—	—	280
2	3	300	—	—	—	—	—	—	420
3	4	400	20	—	—	—	—	—	637
4	5	500	20	—	—	—	—	—	777
5	6	600	30	—	—	—	—	—	956
6	7	700	30	35	—	—	—	—	1,135
7	8	800	40	70	100	—	—	—	1,588
8	8	900	40	70	100	1	—	—	1,721
9	8	1,000	50	70	200	2	—	—	2,138
10	8	1,000	50	70	200	2	50	20	2,478
11	8	1,000	50	70	300	3	50	40	2,941
12	8	1,000	50	70	300	3	50	40	2,941
13	8	1,000	50	70	300	4	50	40	3,007
14	8	1,000	50	70	300	5	50	40	3,087

The details are as follows: *On the first day*, even when hæmatemesis has occurred, the patient receives 7 or 8 ounces of milk (cooled by ice) and two raw beaten eggs, in teaspoonful doses. An icebag is placed over the stomach, and used continuously for ten to fourteen days, to promote contraction, prevent flatulent distension, and relieve pain. *On the second day*, the milk is increased to 10 ounces. Three raw eggs are used, and $\frac{3}{4}$ ounce of sugar. The milk is increased 3 ounces and the eggs one each day until the ninth, and the sugar is gradually increased to 2 ounces. At the end of a week 1 pint of milk and six or eight eggs are used; on the ninth day the milk is increased to $1\frac{3}{4}$ pints. One and a half ounces of raw minced meat are given on the sixth day, and about 3 ounces on the seventh. Zwiebach on the eighth, 2 ounces of raw ham on the tenth, and after this date half the eggs are cooked, the other half given raw. In the third week the patient is put on ordinary mixed diet. In the fifth week she is allowed to get up each day, and in the sixth week she is allowed to go out of doors.

The Dry Protein Diet.—The treatment of gastric and duodenal ulcer by an antilytic serum associated with a dry protein diet is

[1] 1 piece = 20 grammes

much used by some physicians. In 1908 Hort[1] made a report on cases treated by himself. He prescribes absolute rest in bed for two or three weeks, uses no drugs by the mouth, and *does not allow soup, milk, or fish* to any of his cases. The food consists of three or four meals of yolk of eggs lightly cooked, chicken panada or quenelle, and stale bread in rotation, and 10 ounces of hot water at 7 a.m., 11 a.m., and 10 p.m. If the patient progresses favourably, the amount of food is doubled on the fifth day; after the seventh day lightly cooked pounded meat is given; and after the fourteenth day beef and mutton form the chief part of the dietary. Full diet is allowed after three weeks' treatment, but alcohol, soup, tea, coffee, and starchy puddings are forbidden for a period of six months. The antilytic serum consists of the normal serum of the horse, given in doses of 10 c.c. three times a day by the mouth for three weeks; in severe cases a dose of 20 to 30 c.c. is given. It is claimed that the ulcer is healed rapidly by this method. There is an early cessation of pain, vomiting, and bleeding, and a higher level of nutrition is reached than can be obtained by older methods. In a lecture given at a later date, Hort[2] divided his cases into those with and without hæmorrhage.

1. CASES WITHOUT BLEEDING.—Hort considers rest in bed unnecessary except for a few days. The object of treatment is to produce the maximum state of nutrition as rapidly as possible. To attain this end he prescribes the following meals:

Breakfast.—Toast, butter, and eggs.

11 *a.m.*—Raw-beef juice, 2 or 3 ounces.

Lunch, 1 *p.m.*—Beef, mutton, or lamb, lightly cooked, tender, and served in the gravy; one or two rusks and butter. The amount is regulated only by the appetite. No other food is allowed.

Tea.—The same as breakfast.

Dinner, 7 *p.m.*—The same as lunch.

9 *p.m.*—Raw-meat juice, 2 or 3 ounces.

Night.—Sandwiches of pounded chicken or game.

The dietary is continued for one month. The food is eaten dry. *He forbids* milk, tea, coffee, wine, spirits, soup, beef-tea, potatoes, vegetables, farinaceous foods, puddings, cheese, and in many cases withdraws bread and rusks.

2. CASES WITH BLEEDING—*First Day.*—Chicken jelly, two or three teaspoonfuls every three hours alternately with half the yolk of a soft-boiled egg. Cold water, 1 ounce occasionally to relieve thirst. If chicken jelly causes pain, he replaces it by ½ ounce of fresh-meat juice of double the ordinary strength.

Second Day.—Three or four teaspoonfuls of chicken panada, alternately with raw-meat juice or the yolk of soft-boiled egg, every two and a half hours in the day and every four hours at night.

Third Day.—A larger amount of pounded chicken, pounded meat, and yolk of eggs, alternately every three hours. Hot water, 5 ounces, sipped slowly an hour before meals. The *dietary* afterwards is that of non-hæmorrhagic cases.

The experimental observations of Bolton are against the use of meat in the treatment of gastric ulcer. The animals were cats, and the substance used for producing the ulcer consisted of a

[1] *Brit. Med. Jour.*, 1908, ii. 1081. [2] *Ibid.*, 1910, ii. 1904.

gastro-toxic serum obtained by immunizing a goat with the gastric cells of a cat. Two diets were selected for the observations. When the animal was fed on meat, so that the walls of the stomach were exposed to the prolonged action of gastric juice, a slough rapidly formed and separated in *four* days, leaving a clean ulcer. When the animals were fed with milk, a longer period intervened before the separation of the slough and formation of an ulcer. In two cases it did not separate until the eighth day, and in two others it had not separated when the animal was killed on the eleventh day. There is no doubt that this was due to the influence of the gastric contents. The same cause prevented or delayed the healing of the ulcer. After the slough separates, the base of the ulcer is formed of the muscular coat or subperitoneal tissue infiltrated with cells. Towards the end of the second week the deeper layers of the base became fibrous, and the peritoneum thickened, the superficial layers being formed of granulation tissue. At the end of the third week the whole base is formed of fibrous tissue, in which strands of muscular tissue are seen. Until the epithelium has grown over the base, the most superficial layer is formed of vascular and cellular tissue. The mucous membrane is regenerated by the layer of cells upon the surface of the ulcer. This consists at first of a single layer of cubical cells, the glands appearing at first as invaginations of the cubical cells. But there is a difference in the mode of healing in cats fed with milk and those fed with meat. In milk-fed cats the layer of epithelial cells has extended a little way over the base of the ulcer by the tenth or eleventh day; but in meat-fed animals this does not occur until the thirteenth or fourteenth day. In milk-fed animals the base of the ulcer was covered by the twentieth day; but in meat-fed animals a large area in the centre remained uncovered. Bolton[1] drew the following conclusions:

1. The gastric juice plays a considerable part in the production of the ulcer; ulceration is more rapidly produced in the digesting than in the resting stomach, and in the digesting stomach more rapidly in proportion as the gastric juice is a longer period in contact with the wall of the stomach.

2. The ulcer heals more rapidly with a milk diet than with a meat diet. With a milk diet the base of the ulcer is usually completely covered by the twentieth day, but with a meat diet the centre of the same sized ulcer would be uncovered at the same time.

3. In meat-fed animals the base of the ulcer is frequently uncovered on the twentieth day, the granulation tissue at the base of the ulcer having become necrotic. Such an ulcer, however, may only be one-fifth its original size, owing to contraction of the fibrous tissue in the base, although the healing process at the edge has only commenced.

4. In the treatment of an ulcer of the stomach the following principles should be observed:

(*a*) During the early stages the patient should be given food

[1] *Brit. Med. Jour.*, 1910, ii. 1965.

which does not stay long in the stomach, and which does not excite a copious flow of gastric juice; milk in preference to meat.

(*b*) The patient should be confined to bed for at least three weeks.

(*c*) The starvation diet of the older physicians is not necessary, because the nutrition suffers too much, and because ulcers heal well on diets such as the above.

(*d*) In the case of acute ulcers which are extending, and in chronic ulcers, it cannot be expected that healing will take place in three weeks. The ulcer must first be got into a condition for healing, and the rest in bed must be twice as long.

(*e*) Since a condition of hyperacidity exists in many cases of gastric ulcer, and this hyperacidity has a destructive tendency, it should be neutralized by the administration of alkalies. This is not so necessary in acute ulcers as in the chronic form, because the secretion is not hyperacid during the acute stage. When an acute ulcer is experimentally produced, the secretion is diminished in the early stages, but the secretion becomes normal as the ulcer heals.

The Treatment of Duodenal Ulcer is the same as that of gastric ulcer, and no further reference would be necessary except for the dogma promulgated by Moynihan that whenever there is a duodenal ulcer an operation is necessary. This dogma fails to meet universal acceptance, although gastro-enterostomy will cure or relieve the disease. Smith, Hort, and other physicians assert its curability without the aid of surgery. Hort[1] says we know absolutely nothing of the essential nature of duodenal ulcer, but the problem whether it is a disease *sui generis* or a mere symptom of a general disease has a direct bearing on surgical intervention. If it be a local disease, universal excision of the ulcer or of a cylinder of the duodenum, as urged by Moynihan and his followers, would be on a similar footing to the removal of a lipoma. If, on the other hand, it is a symptom of a general disease, as yet unidentified, it assumes a different aspect. Ulcer of the duodenum is often multiple, and associated with secondary ulcers in the stomach, œsophagus, tongue, gums, or cheeks; it has an inveterate tendency to recur through a long series of years, and there is hardly any toxæmic condition in which it may not occur as a purely symptomatic event. What can all this mean but that the ulcer or ulcers of the duodenum are a local expression of some dyscrasia? If this is correct, the mere excision of the local lesion cannot cure the disease. It is as if by amputating the foot with a perforating ulcer we could eliminate the spirochæte, restore the trophic neurons, and prevent recurrence of ulcer in the opposite foot. So long as the unknown cause of the ulcer exists, the ulcer will tend to recur. The meat diet of Hort has already been given. He says[1] the *rationale* of his treatment is as follows:

1. If duodenal ulcer is a symptom and not a disease, the absorption of an adequate amount of protein of a suitable form cannot but increase the resistance of the body to the unknown cause, and assist local repair.

[1] *Brit. Med. Jour.*, 1910, i. 76-78.

2. If protein food is presented to a case of ulcer in which we know the digestive fluids exhibit a high degree of peptic and tryptic activity, some of the pepsin and trypsin molecules will be saturated with the protein. If now, at the height of digestion, we add a **serum** having a high antipepsin and antitrypsin content, some of the unsatisfied pepsin and trypsin molecules will combine therewith, and thus shield the ulcer from those bodies.

3. If an ulcer is constantly bathed in a secretion laden with proteolytic ferments set free by disintegrated leucocytes, other cells, and bacteria, the antitryptic and other inhibitory bodies of the serum cannot fail to have a beneficial value, in the same way as dressing a superficial ulcer bathed in a highly tryptic pus with sterile gauze soaked in normal serum.

Cancer of the Stomach.

The state of nutrition in cancer of the stomach is illustrative of the condition which appertains to this disease in other parts of the body. It has long been known that little or no free hydrochloric acid is found in the carcinomatous stomach. But in 1905 Moore, Roaf, and their collaborateurs showed that the free HCl is absent or diminished in nearly all cases of cancer. They also found that the alkalinity of the blood-plasma was increased in such cases, to which cause they attributed the reduction in the acid-secreting power of the stomach. In the light of the researches of Pawlow, Bayliss, and Starling, the hypochlorhydria in cases of cancer is not merely of academic interest. In it may be found a rational explanation of the profound disturbance of nutrition which is such a common result of cancer. Each stage of digestion is promoted by the activity of the previous secretion. The importance, therefore, of sufficient hydrochloric acid in the gastric juice becomes obvious. In its absence the secretion of pancreatic juice, bile, and succus entericus, and their share of digestion, is deficient. In the light of these facts the distaste for food, the failure of nutrition, and the emaciation, which are marked features in cancerous disease, may be accounted for; although it is possible that they could be explained by the presence in the blood of a toxin elaborated by the cancerous growth; but the existence of such a toxin has not been proved. The increased alkalinity of the blood-plasma has been attributed to an increase in the salts of potassium, and by other authorities to a diminution in the amount of free H ions in the circulating fluids. The failure of nutrition results in a steady and progressive destruction of tissue proteins to supply energy. This is especially noticeable in cancer of the stomach or œsophagus, when only a small amount of food can be got through the stomach. Even when rectal feeding with eggs, peptone, and glucose is resorted to, there is a considerable increase of nitrogen metabolism, due to destruction of tissues.

Treatment.—The dietetics of cancer of the stomach, as in other parts of the body, presents considerable difficulty. The diet must be arranged as far as possible to promote the nutrition of the body

and check the emaciation. In view of the deficiency of free hydrochloric acid, it is desirable that all patients should be given a medicinal dose of hydrochloric acid with each meal. A beverage can be made by mixing the acid in plain water or lemon-water.

(1) When the cancer affects the œsophagus or cardiac end of the stomach, the food should consist of milk, raw eggs, meat essences or extracts, Leube's soluble meat, strong soup, finely minced meat, chicken or fish cream, potato purée, vegetable consommé, fine oatmeal, arrowroot, and other farinaceous foods (Benger's, Allenbury's, Savory and Moore's, Mellin's), dextrin or dextrose, in sufficient quantity to provide for the maintenance of the body. Four pints of milk, 2 ounces of fine oatmeal or corn-meal, 2 ounces of arrowroot or dextrin, 1 ounce of sugar, ½ ounce of butter or an equivalent amount of cream, form a dietary which will yield 2,217 calories. This is little short of the amount required for light work or sedentary occupation. When dysphagia is marked, the patient should be fed three times a day by means of an œsophageal tube, about 1½ pints of food being poured down at each meal. So long as it is possible to pass even a small tube, the patient should be fed in this manner. When it becomes impossible, rectal feeding must be resorted to. Sometimes, after intermitting gastric feeding for a few days, a tube can again be passed through the gullet, and the patient fed as before.

(2) When the cancer is in the *stomach*, but affects neither aperture, the patient may be allowed free choice of food, because, from the nature of the disease, his life will not be long. The cravings of such persons are often remarkable, and, provided the food can easily get in and out of the stomach, no restriction of the diet is necessary. At the same time it is wise to direct the appetite in the right direction. The diminution of hydrochloric acid and the gastric catarrh suggest a dietary similar to that for hypochlorhydria (*q.v.*).

(3) When the *pylorus* is affected, but not obstructed, a mixed protein and carbohydrate diet should be prescribed, and may include milk, eggs, scraped meat, pounded chicken or fish, Leube's solution of meat, kephir, koumiss, junket, custard, Benger's food, Mellin's food, biscuit powder, boiled bread and milk, arrowroot jelly, and other farinaceous foods, and mashed potato. Many of these foods can be peptonized or pancreatized if necessary.

When the pylorus is obstructed, the diet should contain much protein and little carbohydrate. Mellin's food, being almost entirely soluble, may be given; but bread, potatoes, vegetables, arrowroot, cornflour, rusks, biscuits, oatmeal, and all other farinaceous foods should be forbidden; they cannot be digested in the stomach, and their passage into the bowels is hindered. If they are consumed, they will cause flatulence and acidity, increase of pain, fulness, belching, regurgitation, and vomiting. Milk should be the basis of the dietary. Some glucose or dextrin can be used, but not in very great quantity. To these may be added eggs, oysters, meat, fish or chicken creams, meat pastes, meat powders, meat extracts, milk powders, junket, custard, and jelly. A dietary consisting of

4 pints of milk, two raw eggs, and 8 ounces of meat, fish, or chicken, will contain about 146 grammes of available protein, 105 grammes of fat, and 108 grammes of carbohydrate, and yield 2,500 calories of heat or energy. The carbohydrates prescribed will pass through the pylorus if anything will go. The fat is chiefly the fat of milk and eggs, and, being already emulsified, should have no difficulty in passing through a pylorus which is not completely blocked up. Difficulty may arise from the formation of milk curds, but this can be prevented by the addition of 2 grains of citrate of soda to an ounce of milk; it is also obviated by making milk into kephir, junket, or custard. Six or eight eggs may be taken daily if they agree with the patient. The preparation of meat is the most difficult matter. A considerable amount of trouble is required to reduce it to the proper consistence. Raw meat can be put through a mincer, and cooked meat reduced by beating it in a mortar with a pestle. Chicken and fish are reduced by cutting them into very thin slices, beating them to a pulp in a mortar, and adding a little cream or stock to moisten it. It should not be forgotten that absorption from the stomach, never very great, is reduced when the obstruction is marked, and in all cases free hydrochloric acid is deficient. The use of pancreatized or peptonized foods is helpful. Peptonized milk, Carnrich's peptonoids, Leube's meat solution, somatose, nutrose, panapepton, Brand's nutrient powder, Brand's essence of beef, Valentine's meat juice, raw-meat juice, milk fortified by cream, casein, or dried milk, and various other preparations, can be used.

In hæmorrhagic cases the patient should be fed entirely by the rectum for a few days after the cessation of bleeding, and even in non-bleeding cases it is advisable to give the stomach a few days' rest occasionally, and resort to rectal feeding (*q.v.*).

One or two dietaries from other sources may be given as examples. In early cases of carcinoma of the stomach Biedert recommends the following dietary, having a value of 2,300 calories:

6 *a.m.*—Milk, a breakfast-cupful; toast, 1 ounce.
8 *a.m.*—Eggs, two; toast, 1 ounce.
10 *a.m.*—Cream, 4 ounces; zwiebach, two pieces.
Noon.—Meat, 5 ounces; toast, 1½ ounces; cinnamon cake, soda cake, coffee cake, or biscuit, 1 ounce.
4 *p.m.*—Milk-cocoa, a breakfast-cupful; zwiebach, two pieces; fruit jelly.
7 *p.m.*—Rice-milk; zwiebach, two pieces.
10 *p.m.*—Milk, a breakfast-cupful; zwiebach, two pieces.

Wegele recommends for non-obstructed cases:

Morning.—Malt-leguminose cocoa, a breakfast-cupful.
Forenoon.—Kephir, a tumblerful.
Noon.—Malt-leguminose soup, ¼ pint; scraped beef, 3½ ounces.
Afternoon.—Malt-leguminose cocoa, a breakfast-cupful.
Evening.—Scraped ham, 3½ ounces; tapioca, 5 ounces.
10 *p.m.*—Kephir, a tumblerful.
During the Day.—Toast, 2 ounces; honey, 1 ounce (in cocoa); cognac 1 ounce (in kephir).

The entire dietary has a value of about 1,260 calories.

The general treatment of cancer of the stomach is that of relieving pain, acidity, vomiting, flatulence, and constipation. Pain and vomiting are often due to acidity and distension. Antiseptic or disinfecting powders may be given to check fermentation, putrefaction, and flatulence. Flatulence may be relieved by a judicious mixture of cinnamon, cloves, ginger, nutmeg, or fennel with the food. Lavage of the stomach is useful in pyloric cases by removing the micro-organisms responsible for fermentation and distension. Constipation may be relieved by enemata, saline aperient waters, cascara, etc.

When obstruction of the œsophagus or pylorus becomes so great that gastric feeding is more or less impossible, the advisability of an operation will have to be considered. In the meantime rectal and subcutaneous feeding have to be resorted to. Sterilized olive or sesamé oil can be injected into various subcutaneous areas in doses of 3 drachms once a day, but the futility of this proceeding as a means of maintaining nutrition is obvious. When the œsophagus is obstructed, the operation of gastrostomy, to provide a fistulous opening through which food may be introduced into the stomach, is recommended.

When the pylorus is obstructed, gastro-enterostomy should be performed to provide a new *stoma*. By these means considerable suffering may be avoided and the life of the patient prolonged some months. This leads us to consider the digestion of foods after such an operation. The following information is largely drawn from an article on the subject by Hector C. Cameron:[1] Pawlow, Bayliss, and Starling have shown that digestion is a continuous operation, and does not consist of isolated reactions. An adequate secretion of pancreatic fluid depends upon the normal changes of the food during gastric digestion. Therefore the stability of the digestive process is impaired by short-circuiting the duodenum—a link in the chain is broken! Joslin showed that the digestion of fats and proteins was impaired by the operation of gastro-enterostomy. If there is no pyloric obstruction, the food still continues to leave the stomach by the pyloric opening. If there is a pyloric obstruction, it leaves by the anastomotic opening. If the pyloric valve is not absolutely obstructed, as soon as free acid accumulates in the stomach, the pyloric valve relaxes, and a squirt of acid chyme passes through it. Pawlow says this regulating action prevents a disorder of the digestive process, and insures regularity in the transition from the acid gastric to the alkaline intestinal digestion If, however, the acid contents of the stomach pass without control through the anastomosis into the duodenum, the bile, by mixing with the gastric contents, might arrest or weaken the action of pepsin; and an insufficient reduction of acidity would interfere with the pancreatic ferments. A regurgitation of the alkaline duodenal juice is also likely to occur. In consequence of this mixture of secretions, the hydrochloric acid digestion will *a priori*

[1] *Brit. Med. Jour.*, 1908, i. 140.

I. ABSORPTION AFTER GASTRO-ENTEROSTOMY.

Subject and Condition.	Time after Operation.	Diet.	Fat.		Nitrogen.	
			Absorbed.	Not absorbed.	Absorbed.	Not absorbed.
			Per Cent.	Per Cent.	Per Cent.	Per Cent.
Case 1. Non-malignant*	5 months	Mixed	92·30	7·70	91·00	9·00
,, 2. ,, *	7 ,,	,,	92·50	7·50	90·50	9·50
,, 3. ,, *	24 ,,	,,	92·70	7·30	92·10	7·90
,, 4. ,, *	2 ,,	,,	94·70	5·30	92·70	7·30
,, 5. Carcinoma of stomach† ..	—	,,	81·30	18·70	87·40	12·60
,, 6. ,, of pylorus† ..	—	,,	68·79	31·21	80·05	19·95

II. ABSORPTION AFTER GASTRO-ENTEROSTOMY.‡

Condition.	Time after Operation.	Sex and Age.	Kind of Food.	Dry Fæces.	Fat.			Nitrogen.		
					In Food.	In Fæces.	Absorbed.	In Food.	In Urine.	Absorbed.
			C.C.	Grammes.	Grammes.	Grammes.	Per Cent.	Grammes.	Grammes.	Per Cent.
1. Obstruction of pylorus ..	20 days	F., 40	1,700 Milk	25·7	69·0	8·60	87·5	7·2	7·5	97·1
2. Constriction of pylorus ..	36 ,,	F., 52	1,700 Milk	7·7	67·0	17·70	73·7	—	—	—
3. No obstruction, hæmatemesis	11 ,,	M., 53	2,835 Milk	35·1	118·0	15·90	88·6	14·7	11·5	93·9
4. Obstruction, dilatation ..	18 ,,	F., 43	Mixed	23·2	122·5	5·25	95·7	—	—	—
5. Duodenal ulcer	14 ,,	M., 41	,,	41·3	201·5	7·00	93·5	—	—	—
6. Stricture of pylorus ..	8 years	M., 68	,,	35·2	126·5	8·07	91·2	—	—	—
7. Cancer ,, ...	20 days	F., 59	,,	12·6	158·4	5·00	98·0	—	—	—

* Paterson, Hunterian Lectures, Royal College of Surgeons of England, 1906. † Joslin, *Berlin. Klin. Woch.*, 1907, xxxiv.
‡ Cameron *Brit. Med. Journ.*, 1908, i. 144.

be impaired; and, in turn, the diminished or abolished acidity will diminish the production of secretin in the duodenal mucous membrane, and the pancreatic secretion will fail. But a study of the absorption of food after these operations show that the effect is not very deleterious to digestion.

When milk is consumed by a healthy person, the amount of protein absorbed averages about 97 per cent., and the fat varies from 92 to 98 per cent. of the total. After gastro-enterostomy, the absorption is not so complete, but varies with the condition; thus, in non-malignant cases it sinks to 91 or 92 per cent. of protein, as compared with an average of 97 per cent. in health, and 92 or 94 per cent. of fat as compared with 95 per cent. in health. In carcinoma of the stomach or pylorus the absorption of protein sinks to 80-87 per cent., and the fat to 67-81 per cent. This is shown in the table on p. 318.

Hector C. Cameron[1] also gives particulars of the absorption of food after gastro-enterostomy, the diet being milk or mixed food consisting of butter 3 ounces, bread, eggs, fish, vegetables, milk, cream, tea, sugar.

The conclusion derived from these observations is that the operation is not only harmless, but even beneficial, by permitting a greater consumption of food. In non-malignant cases there is a slight diminution in the absorption of fat from a purely milk diet after gastro-enterostomy, partly attributable to a diminution of rennin. The secretion of pepsin and rennin are both somewhat impaired. When a mixed diet rich in fat (chiefly butter) is given, the diminution of digestion and absorption of fat disappears to some extent. With either milk or mixed diet the digestion is the same, whether an obstruction of the pylorus is present or not In malignant obstruction of the pylorus, the operation of gastro-jejunostomy and partial gastrectomy is followed by almost complete power of dealing with the fat. The digestion and absorption of a mixed diet is performed with a comparatively small diminution of the normal percentage of absorption.

Rectal Feeding.

Artificial feeding is a necessity in certain conditions in which it is desirable or imperative to suspend gastric feeding. Ulcer of the stomach and duodenum stand out prominently among the cases in which this mode of treatment is considered necessary; it is also a useful adjunct to other treatment in some cases of gastric dilatation, gastric neurosis, pyloric obstruction, uncontrollable vomiting in pregnancy, and acute gastric catarrh after abdominal operations; in typhoid fever, meningitis, apoplexy, diabetic coma, and other comatose conditions.

Useful as rectal feeding is in such cases, we must not delude ourselves by thinking that the nutritive requirements of the system

[1] *Brit. Med. Jour.*, 1908, i. 143-44.

can be satisfied by this mode of feeding. There are limits to the absorptive power of the intestinal mucous membrane, and these limits are much narrower than formerly supposed. It is impossible to inject foods sufficiently high into the colon to insure the absorption of a large amount of nutriment from its surface. Patients often feel better during rectal feeding because, oral feeding being stopped, the cause of gastric irritation is removed. But a careful record of the metabolism during rectal feeding shows a constant loss of weight, the nitrogenous equilibrium is not maintained; on the other hand, there is a nitrogen deficit, in consequence of which the tissue proteins disintegrate, and part of the excreted nitrogen is from that source. Wynter said: "Nutrient enemata satisfy the mind rather than the body." They remove the sense of hunger, relieve the mental anxiety consequent upon starvation, and in some cases apparently maintain the body in moderate nutrition. These effects may arise from the psychical influence resulting from the use of nutritive materials, and very largely from the absorption of water and salts in the colon. The patient wastes, not merely from absence of food, but from the loss of water; and the absorption of water from the intestinal canal prevents the loss of weight. Rectal feeding is at the best a poor substitute for normal gastric feeding; the patient is in a condition of subnutrition or semi-starvation, and in some cases a decided acidosis arises from tissue destruction and failure to oxidize the fatty acids, and this gives rise to acetonuria and more or less auto-intoxication.

It is necessary to inquire into the extent of absorption of the various foodstuffs from the lower bowel. This has been done by numerous investigators, and an endeavour is made to show the results of some of the observations in the following table. The method of investigation consists of injecting into the previously washed out bowel enemata containing a known quantity of the proximate principles of food; the residue is removed at the next cleansing, and the amount of the proximate principles in it ascertained. The difference between the two is assumed to be absorbed. Each class of materials is separately considered. Voit, Bauer, Ewald, and Huber are among the earlier observers. Their work was valuable, but modern research has shown that the value set upon rectal feeding by them was much too high.

Absorption of Protein.—Arnim Huber, who investigated the absorption by the rectal mucous membrane of human subjects, found that from emulsified eggs 29·8 to 36 per cent. of protein was absorbed. When 1 per cent. of NaCl was added, 69·5 to 70 per cent. was absorbed; and when the egg was peptonized, 74·7 to 76·6 per cent. of the protein was absorbed. But Edsall and Miller, Boyd and Robertson, were unable to confirm this observation, their results are given in table on p. 321.

The best absorption of raw eggs and milk was 21·5 per cent., recorded by Boyd and Robertson; the best absorption of peptonized milk and egg 47 per cent., recorded by Edsall and Miller. When milk

powders were used, an absorption of 40 to 82 per eent. has been recorded. When peptones or albumoses were used, Sharkey[1] found from 50 to 75 per cent., or a total of 51 grammes, absorbed in twenty-four hours. If this is correet, it is possible that more protein can be absorbed than appeared probable from the table. Edsall and Miller endeavoured to aseertain this point by estimating the amount of ethereal sulphates in the urine after rectal feeding. Ethereal sulphates in the urine are inereased in proportion to the amount of putrefaction of protein by bacteria in the intestines. These observers found the excretion of ethereal sulphates after feeding with peptones and albumoses to be exeessive; indeed, it was two or three times as mueh as the normal exeretion. This faet alone places the figures relative to the absorption of proteins at a fictitiously high value. The consideration of the nitrogenous equilibrium shows that, even under the most favourable eireumstanees, this eannot be maintained by reetal feeding, and that sueh alimentation falls far short of the minimum requirements of the system, and necessitates the destruetion of the tissue proteins of the organism to make up the deficieney.

RECTAL ABSORPTION OF EGGS AND MILK.

Food injected.	Food absorbed.			Nitrogen excreted.	Nitrogen Deficit.
	Protein absorbed.	Total Protein absorbed Per Diem.	Nitrogen absorbed Per Diem.		
	Per Cent.	Grammes.	Grammes.	Grammes.	Grammes.
Raw eggs[2]	13·24	9·52	1·52	3·27	−1·73
,, ,, ...	16·50	6·87	1·09	5·50	−4·40
,, ,, ...	21·44	10·52	1·70	2·68	−0·98
,, ,, ...	8·25	3·86	0·61	6·31	−5·69
Peptonized milk and egg[2]	28·90	8·62	1·38	6·87	−5·49
,, ,, ,,	45·30	13·87	2·22	8·12	−5·90
Peptonized milk and egg[3]	39·88	19·00	3·04	10·03	−6·98
,, ,, ,,	47·50	23·81	3·80	12·78	−8·97

Absorption of Fat.—Various investigators report the absorption of different amounts. Aldor found that one person absorbed 33 per cent. of the fat of milk, but another only 1·5 per eent.; Strauss found 10 per cent. absorbed; Edsall and Miller found 13·6 and 33·4 per cent. absorbed by two different people. Boyd and Robertson found the absorption varied from 3·47 to 45·85 grammes per day in different people; Edsall and Miller found from 6·48 to 15·87 grammes absorbed daily. Deucher made investigations whieh led him to suppose that only 10 grammes of fat were absorbed per day through the mueous membrane of the eolon, even with the addition

[1] *Lancet*, 1906, ii. 1262.
[2] Boyd and Robertson, *Scot. Med. and Surg. Jour.*, March, 1906.
[3] Edsall and Miller, *Bull. Univ. Penna.*, 1903, xv. 414.

of salt, and allowing it to remain a long time in the bowel. Hamburger found the absorption of fat was facilitated when it was injected into animals in the form of an emulsion or solution of soap. Munk and Rosenstein made observations in a person who had a fistula into the thoracic duct. The injection of fat into the bowel increased the amount in the chyle, but the increase only indicated an absorption of 3·5 to 5·7 per cent. Boyd and Robertson consider the fat absorbed in this way is a protein-sparer, the loss of nitrogen being greater when the absorption of fat was poor.

Absorption of Carbohydrates.—It appears from the observations of numerous people that sugar disappears from the colon quickly, starch more slowly, and only in part. Deucher gave 200 grammes of sugar daily, and found 77 per cent. absorbed; Zehmisch gave 152 grammes, and found 67 per cent. absorbed; Sharkey gave 34 grammes, and found 78 per cent. absorbed. Boyd and Robertson used pure glucose, and found 90 per cent. absorbed. Strauss considers that 40 to 50 grammes of pure glucose in a 10 or 20 per cent. solution can be absorbed daily, and patients can be maintained in a good condition with it for two or three months. Reach found dextrin to be absorbed better than sugar.

The question has to be asked, What becomes of the sugar? Is it absorbed or split by fermentation? It is possible that a great amount of the sugar injected into the intestine is destroyed by bacterial action, and therefore is not absorbed. To ascertain its value as a nutrient enema, Reach[1] watched its effect on the respiratory quotient. When carbohydrate was given by the mouth, he observed the usual increase in the respiratory quotient, but *the same carbohydrate given as a nutrient enema had little or no influence on the respiratory quotient*, from which he concluded that the proportion of sugar absorbed by the mucous membrane was considerably less than when it was taken by the mouth. When Boyd and Robertson inoculated a solution of glucose with *Bacillus coli communis*, or bowel contents, less than 1 per cent. of sugar was destroyed during a period of four hours at the temperature of the body. They concluded, therefore, that the amount of sugar destroyed in the bowel by bacterial action was of little importance; that the bulk of the sugar which disappears from the bowel is really absorbed, and the absorption amounts to 89, or even 100, per cent. of glucose. In face of the evidence cited we cannot draw definite conclusions as to the value of glucose as a nutrient enema. Further investigation of its effect on the respiratory quotient would probably confirm or destroy the deductions of Reach or Boyd and Robertson. Until evidence is at hand which proves it to be of no value, a 10 or 20 per cent. solution of glucose should be used as a constituent of rectal feeds. Care should be exercised in the choice of the material to be used. Commercial glucose may contain traces of arsenic or sulphuric acid, which would irritate the mucous membrane, and ultimately lead to its ejection. *Pure glucose* should

1 *Archiv f. Exper. Path. u. Pharm.*, 1902, xlvii. 231.

be used, and the addition of ½ to 1 grain of menthol or thymol per ounce will prevent fermentation. It has been found that this combination can be used for weeks together without causing irritation.

Absorption of Salts.—Various inorganic salts are absorbed by the mucous membrane of the colon, provided they are not injected in a too concentrated form, and are not of a nature to induce irritation. The addition of NaCl in the proportion of 1 per cent. is valuable by assisting the solution and absorption of proteins; even fat and carbohydrates are absorbed more readily when it is present. It is considered that salt induces antiperistalsis of the colon whereby the injected material is carried backward as far as the ileo-cæcal valve, or even through this sphincter into the ileum. If this is really the case, it affords an explanation of those cases in which nutrition is said to have been maintained by rectal feeding for weeks or months, for the absorption of nutrients from the mucous membrane of the ileum is undoubtedly greater than that from the colon. But the value of common salt is not universally admitted. This leads to the question of vomiting. The vomiting due to an ulcer of the stomach, gastric dilatation, or pyloric obstruction, usually ceases when nothing at all is given by the mouth, and especially when cessation of gastric feeding is combined with physiological rest of the body. This is aided by the body being scrupulously kept still, turning in bed or shaking the bedstead being avoided. Sometimes, however, vomiting continues in spite of rest and cessation of gastric feeding, and it has been attributed to reflex action due to rectal feeding, and especially to *the use of salt in the enemata.* The state of the mouth, it is true, especially pyorrhœa alveolaris, may cause persistent vomiting if the discharge and microbes are swallowed. When the vomiting is persistent, the local application of mustard, iodine, or turpentine, to the epigastrium may be tried; or small particles of ice or dilute hydrocyanic acid may be given internally. In rare cases the vomiting does not cease until rectal feeding is omitted. In such a case one must, of course, return to oral feeding, beginning to treat an ulcer of the stomach on the lines previously indicated.

Conclusion.—A certain amount of nutriment can be introduced into the system by rectal feeding, but under the most favourable conditions such a mode of feeding results in a condition of decided subnutrition. The amount of protein from raw egg and milk which can be absorbed is really small; that from peptonized milk and egg or peptone is better. Little fat is absorbed, but the carbohydrates, especially glucose and dextrin, are well absorbed. Boyd and Robertson [1] showed that the average amount of albumin absorbed was one-sixth of that injected, of fat one-third, and of carbohydrate nine-tenths. The daily value of the food absorbed varied from 240 to 645 calories, or an average of 390 calories. This is about one-sixth the nutriment required by a person whose metabolism is at a low level. Indeed, while rectal feeding alone is

[1] *Scot. Med. and Surg. Jour.*, March, 1906.

continued, we must expect progressive loss of weight, destruction of tissue proteins, and sometimes acidosis.[1] We cannot, therefore, rely upon this mode of feeding to improve nutrition, but rather to support the body somewhat during a period of functional rest of the stomach. In such cases it is of service, particularly when the enemata consist of predigested proteins, or solutions of peptones and albumoses not exceeding 10 per cent. concentration, with emulsified fat—in the form of milk or yolk of egg, carbohydrates, such as pure glucose or dextrin, up to 10 per cent. concentration, and common salt, in the proportion of 1 per cent. The addition of a little alcohol is also useful; it is held by some that it facilitates the absorption of protein and glucose; it should not form more than 0·5 or 2 per cent. of the injection. The enemata should be siphoned into the bowel by a soft rubber catheter with a long tube and a small funnel. The amount of each feed should not exceed 8 or 10 ounces (250 to 300 c.c.); more than that would render its retention difficult. In this way the injected nutrients may have a value of 2,000 calories, but not more than 25 per cent., or 500 calories, will be absorbed. Examples of the enemata in use are as follows:

1. Singer recommends one raw egg well beaten, 15 grains of salt, milk 5 ounces. Ewald recommends the milk to be peptonized.

2. Huber[2] recommends six raw eggs, to be mixed with 90 grains (6 grammes) of salt; add 7 ounces of dilute hydrochloric acid (0·15 per cent.), containing 75 grains of pepsin. Place the mixture in a warm chamber for ten hours.

3. Boas[3] gives the following: The yolk of two eggs, 4 ounces of milk, 4 ounces of wine, a teaspoonful of peptone, and a little dextrose, all beaten together.

4. Ladevéze[4] gives (1) beef broth 7 ounces, six raw eggs, wine 1 ounce, salt two small teaspoonfuls, to be beaten together: (2) cod-liver oil 5 ounces, yolk of one egg, lime-water 10 ounces; (3) cod-liver oil 5 ounces, yolk of one egg, salt 40 grains, water 10 ounces.

5. Griffiths[5] gives minced beef 5 ounces, Fairchild's peptonizing powder half a tube, a dessertspoonful of glucose and brandy, with a little salt and water; each feed to be 5 or 6 ounces; normal saline solution to be injected at intervals.

6. King[6] gives a raw egg, milk 5 ounces, brandy ½ ounce, laudanum 15 drops; to be peptonized.

7. Ewart[6] prescribes two raw eggs, 1 pint of milk, 3 drachms extract of malt, and a small amount of brandy, by continuous alimentation (see Ulcer of Stomach).

8. Boyd and Robertson[7] prescribe two egg-yolks, pure dextrose

[1] Rolleston and Tebbs, *Brit. Med. Jour.*, July 16, 1904.
[2] *Centralb. f. d. Ges.-Therapie*, March, 1905.
[3] *Brit. Med. Jour.*, 1895, epitome 290.
[4] *Jour. des Méd. Pratiques*, March 25, 1901.
[5] *Brit. Med. Jour.*, 1903, ii. Report of B.M.A. meeting.
[6] *Ibid.* [7] *Scot. Med. and Surg. Jour.*, March, 1906.

30 grammes, salt 0·5 gramme, pancreatized milk 300 c.c.; mix. Approximate value, 300 calories; to be given every six hours.

9. Beaumetz prescribed the yolk of one egg, $\frac{1}{4}$ pint of milk, 1 ounce of liquid peptone, 5 drops of laudanum, salt 15 grains, bicarbonate of soda 8 grains.

10. Edsall and Miller gave six raw eggs, 400 c.c. of milk, salt and pancreatin. Sufficient for twenty-four hours; to be given in three feeds.

11. Boyd and Robertson also used the white of one egg, 200 c.c. of milk, salt, a spoonful of dextrose, water to 300 c.c., pancreatized and sterilized; repeated four times in twenty-four hours.

12. Leube recommended 150 to 300 grammes of meat free from fat, and 50 to 100 grammes of pancreas, to be finely minced, and beaten together with a pestle and mortar, a little warm water being added to bring the mixture to the consistence of cream; 25 to 50 grammes of butter may be mixed in while beating the minced meat. It should be injected warm.

13. Fleiner[1] gives (1) meat broth $8\frac{3}{4}$ to $10\frac{1}{2}$ ounces, plus $1\frac{3}{4}$ to $3\frac{1}{2}$ ounces of white wine; (2) the same, with one or two beaten raw eggs; (3) milk with glucose and salt.

[1] *Münch. Med. Woch.*, 1902, Nos. 22-24.

CHAPTER X

DISEASES OF THE INTESTINES

Intestinal Indigestion and Auto-Intoxication.

The processes of digestion and absorption have been described in previous chapters. To insure digestion and absorption taking place in a normal manner, there must be complete harmony between the organs concerned. Failure in the performance of a function by the stomach, liver, pancreas, or bowels, will be followed by derangement of the others. Primary intestinal indigestion is due to a deficiency in the quantity or quality of the intestinal, hepatic, or pancreatic secretions, or some disease of the intestinal mucosa. Secondary intestinal indigestion arises from chronic intestinal catarrh, such as commonly follows the passive congestion due to diseases of the heart, liver, or lungs. It may also arise from irregularities in feeding, atony of the stomach, hypochlorhydria, and even from hyperchlorhydria. Excessive acidity checks pancreatic digestion; the activity of trypsin is hindered, the absorption of fat delayed, and the due transformation of carbohydrates prevented. Deficiency in the pancreatic secretion has a similar effect; a considerable proportion of the protein is unassimilated, and fat leaves the body in the fæces. Deficiency of bile leads to lessened absorption of fat, constipation, clay-coloured stools, and catarrh of the bowels. Fermentation occurs as a consequence of these defects. The normal gastric juice is disinfectant, but even in health this influence only extends to the duodenum. Bile is also antiseptic. The pancreatic fluid, on the other hand, is favourable to the action of bacteria. Indeed, it is difficult to say where the action of pancreatic fluid ends and that of bacteria begins. Many intestinal bacteria have a diastatic and proteolytic action, somewhat similar to that of the pancreatic secretion; but their action goes farther. Lactic acid bacteria, of which there are many kinds, are introduced into the body with milk, cheese, or butter, and transform saccharose, lactose, and dextrose into lactic acid. Butyric acid bacteria, several kinds of which are also introduced with the food, transform cane-sugar and lactic acid into butyric acid, hydrogen, and CO_2. Yeast transforms dextrose into alcohol, succinic acid, and glycerine. *Mycoderma aceti* and other micro-organisms transform carbohydrates and alcohol into acetic acid, water, and CO_2. Other bacteria split fats into fatty acids and glycerine, and some

fatty acids into butyric and valeric acids. Putrefactive organisms transform proteins into fatty acids and amino-acids—*e.g.*, leucin, tyrosin, indol, skatol; aromatic bodies—*e.g.*, phenol and cresol; purin bodies—xanthin, hypoxanthin, guanin, and adenin; ptomaines, such as neurin, cholin, muscarin, cadaverin, peptotoxin, putrescin, and saprin; ammonia, compounds of ammonia, salts of potash, sulphuric acid, methyl mercaptan, and sulphuretted hydrogen. These substances cause—

Auto-Intoxication.—The fact that auto-intoxication arising from these causes is not more common is due (1) to the antagonism of the poisons; (2) to the action of the liver, which, in its normal condition, has the power of destroying, modifying, or eliminating some of them; and (3) because some of the poisons are broken down into harmless substances. When the neurons undergo degeneration, the symptoms of general paralysis are due to neurin and cholin. When absorbed from the alimentary canal in frequently repeated small doses, neurin and cholin may cause other nervous diseases. These poisons arise from the decomposition of various foodstuffs. Lecithin, a normal constituent of many cells, is broken down in the intestinal tract by the pancreatic secretion or by bacteria into fatty acid, glycerine, phosphoric acid, and cholin. Neurin is broken down to cholin. And cholin is normally broken down to CH_4, CO_2, and ammonia. But if the decomposition of proteins containing these bodies is incomplete, the neurin and cholin may be absorbed unchanged. It is believed that cholin is the chief cause of the unpleasant symptoms sometimes arising after the consumption of fresh or new-laid eggs. Indol, skatol, and phenol, are also absorbed from the alimentary canal. Indol is usually converted into indican and excreted by the kidneys; skatol is oxidized to skatoxyl, and excreted in the urine as skatoxyl-sulphuric acid. These substances form the ethereal sulphates of the urine, and the proportion to nitrogen in the urine is a rough measure of the decomposition of proteins in the bowels.

The results of intestinal indigestion are—(1) flatulence and failure of nutrition, owing to decomposition of the food; (2) alimentary toxæmia from absorption of the products of decomposition.

Flatulence has been sufficiently discussed. The patient should avoid those foods which give rise to it. The carbohydrates must temporarily be reduced. Those which commonly give rise to most gas are bread, potatoes, and legumes A large proportion of these substances is carried down into the ileum, where the alkalinity and slow peristalsis favour bacterial growth and fermentation. Sago, rice, tapioca, and arrowroot do not give rise to flatulence in the same degree—in fact, rice is absorbed almost entirely in the upper part of the bowels. It is therefore advisable to recommend such people to eat rice, sago, tapioca, arrowroot, and *stewed fruits*. The organic acids of the latter being conveyed into the intestines, assist in checking bacterial growth, while they do not interfere with digestion.

The acidity of the stomach and heartburn, which frequently accompany intestinal indigestion, are often treated by the administration of alkalies between meals or by drinking water. The latter expedient relieves the organic acidity by diluting the contents of the stomach, the former by neutralizing the acidity. But neither procedure is a curative measure. Indeed, the administration of alkalies between meals favours the growth of bacteria in the stomach and bowels, and tends to exaggerate the evil it is sought to cure. Alkalies taken *before meals* may, on the other hand, increase the secretion of hydrochloric acid slightly. But the best treatment is to forbid eating carbohydrate foods for a few days, and prescribe hydrochloric acid to disinfect the stomach, intensify the acidity of the chyme, and promote the formation of *secretin* and secretion of pancreatic juice. The dietetic treatment of intestinal flatulence and failure of nutrition consists of a combination of meat and milk. During the period of one week the patient should take daily 2 pints of milk (used as plain milk, custard, junket, or milk jelly), jelly of various kinds, and meat, fish, or poultry. After this period rice or rice pudding may be allowed, but with very little sugar, or with very little spice. If no flatulence follows this addition to the diet, some tapioca, sago, or arrowroot may be allowed next, taking care that the sugar is kept at a minimum; and finally torrefied bread, very dry toast, or zwiebach; and, last of all, potatoes. The green vegetables, salads, and legumes must be taken sparingly for a long time. Kidney or string beans, vegetable marrow, and spinach, are probably the least flatulent, and they may be taken first of all.

The Alimentary Toxæmia arising from intestinal indigestion is followed by more serious consequences. For the sake of avoiding repetition, it will be dealt with here instead of elsewhere. Auto-intoxication arises from (1) the excessive formation of toxins, or (2) defective elimination Toxins arise from protein foods if these are taken in excess or in an improper condition, and from torpidity or stasis of the contents of the bowels, with subsequent fermentation or putrefaction. Toxæmia may arise from atony of the small or large intestines, duodenal atony or catarrh, dilatation of the stomach, hypochlorhydria, and defective action of the nervous system. Defective elimination is due to a failure to oxidize the leucomaines and ptomaines arising from the food, or inability to eliminate the oxidation products. The modes of elimination are as follows:

1. *The liver* normally destroys leucomaines, ptomaines, purin bodies, and even peptones and albumoses. Its destructive functions are exceedingly important. Anything which interferes with the functions of the liver for any length of time necessarily leads to auto-intoxication and serious deterioration of the health.

2. *The kidneys*, however, are by far the most important organs of elimination. They eliminate two-thirds of the waste solids, including urea, uric acid, purin bodies, ethereal sulphates, colouring, and mineral matters.

3. *The lungs* eliminate various poisonous substances, even when the body is in a normal condition, including a little ammonia, marsh gas, and organic volatile bodies. Germain Sée experimented with a liquid obtained by washing expired air, and found it to be poisonous to small animals. If such bodies are exhaled by the lungs when the organism is in a state of health, how much more will they be exhaled when the body is diseased! When the bowels are not acting regularly, the lungs excrete a large amount of odoriferous substances belonging to the indol group, which are of a distinctly toxic character. It is fortunate that volatile substances of this nature diffuse through the air in the lungs and leave the body so easily.

4. *The skin* normally eliminates CO_2, a little urea, a small quantity of salts, and some volatile fatty acids, which give a characteristic odour to certain animals, and even to human beings. It is interesting to note that fatty acids are eliminated by the skin of hypochondriacs more freely than that of ordinary human beings.

A careful study of intestinal auto-intoxication will throw much light on the ætiology of many chronic and intractable ailments. Ptomaines, or substances arising from putrefying bodies, have long been recognized as a cause of dangerous illness. But it was not until 1885, when Gautier demonstrated the poisonous nature of leucomaines and ptomaines, and they were considered of pathological interest. Gautier showed that the animal economy is often poisoned by its own products—that is, by leucomaines arising during metabolism. *The leucomaines* found in fresh muscular tissue are xantho-creatinin, crusco-creatinin, ampho-creatinin, and pseudo-creatinin. *The ptomaines* arise from albuminous bodies during putrefaction, and may be divided into two groups: (1) *The little poisonous—e.g.*, putrescin, $C_4H_{12}N_2$, derived from all kinds of albuminoids; neuridin, $C_5H_{14}N_2$, from meat; saprin, $C_5H_{16}N_2$, from all kinds of albumin; cadaverin, $C_5H_{17}N_2$; cholin, $C_5H_{15}NO_2$; gadinin, $C_7H_{17}NO_2$, from cod-fish. (2) *Very poisonous—e.g.*, neurin, $C_5H_{13}NO$; muscarin, $C_5H_{13}NO_3$; peptotoxin; mydaleïn; ethylendiamine, $C_2H_4(NH_2)_2$; tyrotoxicon, $C_6H_5N_2$, from decaying cheese and ice-cream; mytilotoxin, $C_7H_{15}NO_3$, from mussels; scombrin, $C_{17}H_{38}N_4$, from mackerel; sardinin, $C_{11}H_{11}NO_2$, from sardines, etc.

Some products of normal intestinal digestion are poisons of considerable power, and if, through inadequacy of the cells of the intestinal mucous membrane, these poisons reach the circulation in a considerable quantity, dangerous, and even alarming, symptoms may ensue. The knowledge that the proteins of the food are broken down in the intestines into amino-acids, some of which are very poisonous, and are taken up by the cells of the mucous membrane and reconstructed therein into new proteins, places the intestinal mucous membrane on a higher plane of physiological importance than it was considered to occupy before the recent knowledge of amino-acids was arrived at.

One of the commonest modes of causing a toxæmia is by constipation or a delay in the process of digestion and absorption. The longer the contents remain in the ileum and colon, the more opportunity is afforded the bacteria to bring about putrefactive changes. The slow peristalsis which occurs in atony of the intestines particularly favours bacterial action. The commonest symptoms arising from such toxæmia are dyspepsia, bilious attacks, constipation, or constipation alternating with diarrhœa, foul breath, flatulence, headache, vertigo, migraine, neuralgia, pigmentation of the skin and conjunctiva, cold hands and feet, etc. The chronic results of such toxæmia have been classified as follows: (1) Gout, especially the neurotic and so-called " latent " gout; (2) chronic rheumatism, and probably rheumatoid arthritis; (3) asthma, chronic bronchitis, wheezing, especially in the obese; (4) vasomotor disturbances, cardiac irregularity, cardiac neuroses, false angina, coldness of the hands and feet, pseudo-Raynaud's disease; (5) arterio-sclerosis and Bright's disease; (6) neurasthenia, migraine, insomnia, hypochondria, and other forms of mental derangement.

Gout and chronic rheumatism are probably always associated with more or less intestinal auto-intoxication, and in many instances are due to this cause. Whether we view gout as being due to an excess of animal food, purin bodies, mal-digestion of carbohydrates, or imprudent mixing of foods and drink, in each case the toxins may be produced in the intestinal canal. Whether we view gout as being due to defective action of the kidneys, inactivity of the liver, dilatation of the stomach, or want of exercise, the main factor in each is excessive formation or defective elimination of the materies morbi, arising in the alimentary canal, and therefore an auto-intoxication.

Probably no part of the body is more often affected by the products arising from protein decomposition in the bowels than the bloodvessels. The multitude of toxins arising in the alimentary canal have been divided into two classes: (1) Those which exercise a hypotonic or relaxing effect on the vessels, and lower the blood-pressure; (2) those which have a hypertonic or constricting effect, and raise the blood-pressure. The poison or poisons circulating in the blood-plasma give rise to **arterio-sclerosis,** either directly by causing hyperplasia of the cellular elements, or indirectly by causing a supernormal blood-pressure or hypertonus. That morbid blood-plasma may cause arterio-sclerosis by hyperplasia is shown by the widespread thickening of arteries which occurs in some persons with hypotonus or persistent low blood-pressure. But the chief cause of arterio-sclerosis is a persistent high blood-pressure. There is but one cause of a persistent supernormal pressure—viz., arterial hypertonus—and but one cause of a persistent hypertonus—viz., some morbid element in the blood-plasma. It must therefore be admitted that the vaso-constrictor poisons arising from the alimentary canal play a prominent part in the causation of arterio-sclerosis. Russell contends that such alimentary poisons are the

cause of most of the cases of arterio-sclerosis which are independent of renal disease. The most pernicious alimentary toxins are those arising from protein decomposition, and those arising from animal proteins are said to be more poisonous than those from vegetable proteins.

The Treatment of Alimentary Toxæmia.—The first thing is to see that the food itself is free from bacterial organisms of an injurious character. The second, that the food is of such a character that it will not favour bacterial fermentation. Thirdly, moderation in diet, and especially animal food, is essential. There is no need to exclude animal food altogether. Although it is said that animal proteins are more prone to bacterial decomposition than vegetable proteins, it should be remembered that they are both composed of amino-acids, frequently the same kinds, although the proportions are different—in fact, the animal proteins of our food were constructed out of vegetable proteins consumed by the animals. Furthermore, it has never been shown that animal proteins behave in the body differently from vegetable proteins. Intestinal putrefaction is directly proportional to the amount of proteins in the food. It is true there is a great difference in the amount of indol produced from foods. Zuntz found more indol is produced from meat than from vegetables. The food, therefore, should contain a small amount of meat, fish, or fowl; while a free use of the legumes (peas, beans, lentils and peanuts) should be encouraged. Milk and cream can be used in moderation. A course of *lacto-vegetarian* dietary may be tried, and is often extremely useful, not only as a preventative of toxæmia, but to counteract constipation.

There is a difference in the effect of carbohydrate foods. Bread, potatoes, and legumes give rise to most organic acids and flatulence, because a considerable proportion of them is carried down into the ileum, where the alkalinity and slower peristalsis favour bacterial action. Rice, sago, tapioca, and arrowroot, being absorbed almost entirely in the jejunum or upper part of the ileum, may be consumed with stewed fruits, the acidity of which assists in checking bacterial growth. The rest of the food may consist of a *little* bread-and-butter, a small amount of roasted or grilled meat, cooked vegetables, milk, and a little red wine. The patient should avoid most kinds of fish, game, pork, veal, hashed meat, stews, rich gravy, soups, meat extract, pastry, cheese, tea, and coffee. *Sour milk* has been used for some time as a remedy for intestinal fermentations, especially that soured by the Bulgarian bacillus of Massol. Whey and buttermilk are likewise useful.

Acidosis, or Acid Intoxication (see chapter on Diabetes).—A similar defect in metabolism of fat in children causes acidosis. The diet should consist chiefly of proteins and some carbohydrates. Fat should be restricted.

Diarrhœa.

A too frequent evacuation of the bowels arises from many causes. The commonest causes are impurities in the food, air, or water. It may arise from atmospheric changes, nervous influences, enteric catarrh, dysentery, cholera, typhoid or tuberculous ulcerations, lardaceous disease, and various poisons in the blood. The term "diarrhœa" is more or less a relative one. Some persons are regularly moved two or three times a day, and do not feel well if they are not; but people who are moved but once a day, or on alternate days when in health, would consider two or three evacuations a day, even though the stools were only soft and mushy, to constitute diarrhœa. Much depends on habit. Diarrhœa is most common in the summer or autumn, but it is promoted by alternate hot and rainy weather. It is most likely to affect people who are already in a state of ill-health, who are badly fed, who suffer from alcoholism or chronic diseases. Some people are never free from it; two or three evacuations occur every morning, with a little griping pain. This may be salutary, especially when it follows excessive eating, the consumption of unsuitable foods, or afflicts people who are subject to Bright's disease. But if it occurs throughout the day, it should be regarded with suspicion, as tending towards enteric fever, dysentery, cholera, or some other disease.

A few of the causes of diarrhœa may be detailed. When it results from the action of drugs, it passes off with the effect of the medicine. Many drugs quicken the peristaltic movement, and hurry the food and secretions along the ileum into the colon before there is time for absorption. Some, however, have little or no effect on the secretion or absorption, except by increasing the peristalsis. Others, like the salines, cause a profuse secretion of fluid, but have little or no effect upon peristalsis; whence the advisability of combining salines with aperients which stimulate peristalsis. Diarrhœa resulting from chills is probably due to an acute catarrh. Nervous diarrhœa is due to mental emotion, and, like "student's diarrhœa," is often very troublesome. "Morning diarrhœa" is often associated with alcoholism, dilatation of the stomach, chronic intestinal catarrh, or ulceration of the sigmoid flexure. It may be due to entozoa. It sometimes affects those suffering from Bright's disease. When it is due to the elimination of toxins through the intestinal mucous membrane, which are normally excreted by the kidneys, it probably has a salutary effect by averting a threatened uræmia.

The consumption of ordinary food is not likely to cause diarrhœa in a normal individual, but certain persons are liable to an attack of diarrhœa after the consumption of eggs or fatty food. The imperfect digestion of certain foods will also cause it. The formation of toxins by the decomposition of proteins in the bowels by the normal flora will give rise to it. But the diarrhœa which may occur from foods such as cheese, ice-creams, stale meat, high-kept game,

mackerel, and other fish, is due to the toxins existing in them at the time of consumption.

The fæces normally contain an immense number of bacteria, and the quantity evacuated daily amounts to many millions. If the fæces are retained too long in the intestines, the action of such bacteria may give rise to diarrhœa. But the normal fæces have only a slight pathogenic power. The *Bacillus coli communis* is usually a harmless organism, but this harmlessness is said to be due to the protective action of the intestinal epithelium, which prevents the absorption of its toxins or the invasion of the tissues by the bacilli. Various lesions, however, may interfere with this protective influence—*e.g.*, hyperæmia, desquamation of the epithelium, and the action of certain bodies such as butyric acid (always poisonous), and other toxins which produce actual changes in its walls. In such cases the *B. coli* obtains pathogenicity, and may lead to diarrhœa; indeed, Lesage considers that 25 per cent. of cases of diarrhœa occurring in breast-fed infants are due to this cause. There are, however, many varieties of *B. coli*, and Escherich is of opinion that *B. coli communis* is not concerned in the production of diarrhœa; but it is held to be responsible for many outbreaks of diarrhœa by other authorities, who are fully aware of the error of mistaking this bacillus for allied varieties. The *Bacillus B.* of Duval, which approaches the colon bacillus in character, occurs in many fæces during summer diarrhœa. Diarrhœa is very often caused by bacteria introduced with the food or drink. *Staphylococcus pyogenes aureus* from sore nipples may be taken into the organism of breast-fed babies. Streptococci are only slightly pathogenic, but they irritate the intestinal mucous membrane, and render it vulnerable to other bacteria. *Streptococcus longus* in the milk of cows suffering from mastitis often causes diarrhœa. Many epidemics of food-poisoning have been due to the *Bacillus enteritidis* of Gärtner, which is found in the food and fæces; and a group of allied organisms, named by Durham *B. ærtryke*, frequently occur in diseased meat. The food may be contaminated with *B. enteritidis sporogenes* of Klein, *B. botulinus*, *B. putrificus*, or other organisms capable of causing diarrhœa, ptomaine-poisoning; etc. Specific diarrhœas are due to *B. tuberculosis*, *B. typhosus*, *B. choleræ*, etc. *B. dysenteriæ*, many types of which have been isolated by Shiga, Flexner, and others, is now considered to be the ordinary cause of dysentery, although some cases are due to amœbæ. "Asylum dysentery" is due to Shiga's bacillus.

The Treatment of Diarrhœa.—A discovery of the cause is important and almost essential to the correct treatment of the disease. Absolute rest in bed or in the recumbent posture should be insisted on to avoid movements of the body. The application of warmth to the abdomen will assist in relieving cramp or griping pain. The administration of an aperient, such as castor-oil or rhubarb, is necessary to remove any remnants of decomposing food or undigested material which irritates the mucous membrane. This may

be sufficient treatment in many cases of simple non-fermentative diarrhœa. The food, however, must be such as will not irritate the intestinal mucosa, and will leave as little residue as possible. If the disease is very acute or severe, all food must be withheld for a day or two, not only to avoid irritating the mucous membrane, but to minimize peristalsis as much as possible. Barley-water or alum whey may, however, be allowed in small quantities; but it should be sipped, and not taken in mouthfuls. When the symptoms are somewhat abated, begin feeding by giving milk and lime-water, albumin-water, lemon-water and white of egg, alum whey, ordinary whey or buttermilk, raw-meat juice, and a little red wine and water. The use of stimulants has to be considered. Red wine as a rule is permissible, and there is no doubt that the administration of 1 ounce of good brandy at a single dose and almost neat is a useful remedy in many attacks of simple diarrhœa. It is not quite clear how the brandy acts, but it probably does so by paralyzing the movements of the bowels and preventing peristaltic action; as a secondary effect it checks pain, and especially the irregular sensation of cramp or griping due to unequal peristaltic movements. Lime also checks the peristaltic movement of the bowels by inhibiting the involuntary muscular fibres; the action of chalk mixtures in curing diarrhœa is partly due to this effect of calcium salts. But lime has another effect. The fatty acids which arise from protein decomposition or exist preformed in the consumed food act as powerful irritants to the mucous membrane, and stimulate peristalsis. This effect is prevented by neutralizing the acids, whether belonging to the fatty acid series or not, with chalk; insoluble soaps are thereby formed, and a thin pellicle is spread over the mucous surface, which protects it from irritation by other substances.

When the symptoms have abated still more, we may proceed to give other food. If an inflammatory or acute catarrhal condition exists, it is proper to reduce the carbohydrates and give only protein and fat in the food for a time. For this purpose a pure milk diet is useful. The amount of carbohydrate contained in it is not excessive, and it leaves a small residue. There is no reason for supposing that milk *per se* has any influence on the bacterial flora, but the lactose provides nutriment for the *B. lacticus*, and increases the acidity of the intestinal contents, and is thereby directly antagonistic to the putrefying organisms. The milk may be given as plain milk, milk and lime-water, junket, koumiss, kephir, and other sour-milk preparations. This treatment may be followed by raw-meat juice, the pulp of underdone meat, chicken soufflé, etc.

When there has been a decomposition of proteins, as in cases of diarrhœa from meat-poisoning, ptomaine-poisoning, and decomposition within the intestinal canal, a combination of milk and carbohydrates is the best. The milk may have rice boiled in it (*rice-milk*), or it may be thickened with arrowroot or cornflour, biscuit powder, Benger's, or other farinaceous foods. The white of an egg can be

given in a teacupful of milk, and a little nutmeg, cinnamon, or ginger may be added. Carminatives relieve the pain of diarrhœa by lessening spasm or causing the peristaltic movements to be more even and regular; they also assist in expelling flatus, which is a frequent cause of pain and irregular peristaltic movement. Sometimes milk disagrees with the patient. In such a case the food must consist of sago, tapioca, or rice, cooked in water until it is a jelly, flavoured with cinnamon or nutmeg, cream being added when it is served. As a general rule soup, broth, and all meat extracts are to be forbidden in cases of diarrhœa. But if people cannot take milk, we may allow the least irritating forms of meat essences, such as Brand's essence, Mosquera's meat jelly; and chicken or veal broth, thickened with flour, arrowroot, or ground rice.

When the diarrhœa is passing off, the return to ordinary diet should be gradual. A little clear soup, mutton or chicken broth, with dry toast or stale bread in it, may form an early meal. Then custard, junket, jelly, or milk pudding may be taken. The next day a bit of sole, plaice, or whiting, and mashed potato, may form the meal; then boiled mutton or chicken. Care must be taken to avoid any substance likely to irritate the intestinal mucous membrane. If the attack has been at all severe, the patient must for some time avoid all uncooked fruit or vegetables, all stringy and fibrous fruits, brown or wholemeal bread, pickles, pork, pastry, the skin and gristly portions of meat, poultry, fish, etc.

A few special varieties of diarrhœa require a little consideration. **Morning diarrhœa** should be treated by a light diet, free from all kinds of irritating substances. All liquids should be taken early in the day, and no fluids drank after 5 p.m. **Evening diarrhœa** is also often checked by taking no liquids in the early part of the day—say until the midday meal. In both these forms it is requisite to keep a watchful eye over the consumption of alcohol.

Diarrhœa in *tropical climates* should be treated by a period of absolute rest in bed and an absolute milk diet. It may be due to sprue, which is considered below.

In the acute stage of *dysentery* the vomiting may be checked by a mustard plaster applied to the epigastrium; pain and tenderness of the abdomen by warm applications. The food should consist of albumin-water, rice-water, barley-water, chicken or mutton broth, *until the tongue is clean;* then add milk, custard, junket, jelly, blanc-mange, weak gruel (especially arrowroot), raw eggs, barley-water, and other demulcent drinks. Red wine may be beneficial, and brandy is sometimes prescribed up to 2 or 3 ounces daily. Vegetables and fruit must be *avoided,* also beef-tea, meat extracts, and peptones. "Asylum dysentery" requires a similar dietary.

When *cholera* attacks a person, the treatment must be the same as for acute diarrhœa of bacterial origin. The vomiting may be checked by ice, ice-water, effervescing draughts, champagne, or brandy-and-soda. Advantage must be taken of pauses in the vomiting to give the patient some food. At first the diet must

consist of whey, buttermilk, koumiss, or kephir. If milk must be given, owing to the former articles not being at hand, it should be combined with sodium citrate, to prevent the formation of curds. White of egg and lemon-water may be of advantage in checking the vomiting, and at the same time a means of introducing a little food. Veal broth or chicken broth may be given. The use of beef-tea and meat extracts is forbidden, but there are some cases where the stimulating properties of xanthin and creatin are advantageous, especially when the patient is collapsed. The use of Valentine's meat juice, raw-meat juice, Brand's essence, or Bovinine, in small doses then may be beneficial. Collapse must be met by brandy or champagne, various drugs, and saline injections into the subcutaneous tissues; and the use of hot-water bottles to the feet and sides, a hot-water bag or other warm application to the abdomen, a mustard-plaster over the heart, and wrapping the patient in blankets. As soon as the vomiting is checked, raw eggs and milk, custard, junket, or jelly, may be given.

When the diarrhœa is associated with *peritonitis*, and frequent vomiting prevents very much food being given by the mouth, abstinence from food for twenty-four hours may be a better method of treatment than attempts at feeding. But if it seems desirable to give anything during the vomiting, it should be only a little Valentine's meat juice, Brand's essence of beef, or other meat jelly, and albumin-water or white of egg and lemon-water. When the vomiting ceases, milk and sodium citrate, junket, custard, or jelly, may be given in teaspoonful doses every few minutes, and the diet gradually built up on the lines already indicated.

Diarrhœa may be due to *tuberculous ulceration of the bowels*; this should be suspected when a long-continued diarrhœa exists in connection with abdominal pain or tenderness and tumidity of the abdomen, especially if the diarrhœa is accompanied by slight hæmorrhages from the bowels. The discovery of *Bacillus tuberculosis* in the fæces or sputum would be confirmatory evidence of its existence. The diarrhœa alone is not sufficient to establish a diagnosis. The food should be bland and unirritating. Eggs, milk, pounded chicken or fish, chicken broth or veal broth, farinaceous foods, such as Mellin's, Benger's, Savory and Moore's. If the milk is not absorbed, as shown by the presence of curds in the stools, add sodium citrate to it, or peptonize it; if it does not appear to be absorbed when treated thus, it must be omitted.

Chronic Diarrhœa may be due to a continuance of any of the fore-mentioned causes. A prolonged fermentation in the small intestines gives rise to that condition called by Nothnagel "acid jejunal diarrhœa," and another variety called by Schmidt and Strassburger "intestinal fermentation dyspepsia." The diarrhœa may be of a **continuous** character—that is, frequent loose motions occurring from day to day, the stools being excessively acid, and frequently frothy. It may be of an **alternative** character, the diarrhœa consisting of the discharge of thin or soft fæces, combined

with mucus, and accompanied by pain, alternating with constipation. It may be of a **lienteric** character, the food being hurried rapidly along the alimentary canal, so that undigested foodstuffs appear in the fæces soon after meals, or the fæces are evacuated in an unformed or pultaceous mass. It may be of a **colliquative** character, the diarrhœa consisting of profuse liquid stools, and more or less exhausting in its effects.

Treatment.—In chronic diarrhœa it is probably more important to insist upon what the patient should not take than on what should be eaten. However carefully planned the diet may be, the neglect to instil into the patient's mind a knowledge of what should be *avoided* would certainly be an error. It is not sufficient to tell him to avoid indigestible articles of food, pastry, vegetables, and raw fruit. He must be careful to remove "all skins and bones, strings and stones" (Brunton). If these cannot be removed from the food, it must be rejected. They include the skin and gristly portions of all kinds of meat, fowl, game, and fish; the stringy fibres in meat, sinews in all kinds of birds; the scales of sardines, pilchards, herrings, trout; the bones of sardines, and spicula of bone from other flesh foods; sardines and whitebait should be rejected. The skins of vegetables—*e.g.*, potatoes and tomatoes—should be removed; also the skins of apples, pears, peaches, apricots, plums, gooseberries, and grapes. Currants, raisins, and marmalade should be avoided. The strings in various fruits should be removed—bananas, oranges, peaches, apples, and pears. The strings in vegetables should be removed; peas, beans, carrots, turnips, cabbage, cauliflower, asparagus, etc., should be rejected. The seeds should be removed from all fruits—grapes, currants, gooseberries, strawberries, and raspberries. All kinds of nuts should be rejected. In general, the patient should avoid all fatty and greasy foods, rich food, pork, veal, duck, goose, salmon, mackerel, coarse or tough meat, hashed meat; salted, smoked, pickled, or dried meat and fish; strong soup of all kinds, beef-tea, meat extracts; pies, pastry, cakes, sweet foods, confectionery; sweet wines, syrups, and malt liquors; fibrous vegetables, cabbage, savoy, salads, and raw vegetables; brown or wholemeal bread, rye bread, oatmeal, porridge, maize-meal, hominy; sweet potatoes, yams, artichokes, pickles; all laxative fruits such as rhubarb and prunes; figs, dates, nuts, and most kinds of raw fruit.

The best diet is undoubtedly one consisting wholly of milk, eggs, scraped meat, and foods which have been reduced to a pulp and passed through a sieve. This is not always obtainable, but it should be carried out as nearly as possible. Scraped meat, to the extent of 1 pound a day, is very beneficial. Milk should be boiled, but may be drunk warm or cold according to taste, and alone or with lime-water, barley-water, Perrier, Salutaris, or other aerated waters. It can also be given in the form of junket, custard, or jelly made with isinglass or ordinary table jellies; blanc-mange, arrowroot, cornflour; or as milk-soup flavoured with celery, essence

of celery, or celery salt; it can be peptonized, or fortified with dried milk powder or casein-preparations; or taken in the form of koumiss, kephir, or yaourte. Well-cooked milk puddings are allowable in many cases, unless there is reason to avoid carbohydrates (fermentative diarrhœa); rice, sago, tapioca, macaroni, and vermicelli (but not semolina, pearl barley, or groats). Eggs may be taken raw, poached, or boiled; buttered or scrambled eggs are allowable sometimes, but not in all cases, owing to the quantity of butter used in their preparation. Weak soups are allowed to most patients—*e.g.*, mutton broth, chicken broth, veal broth; they can be flavoured with mint, thyme, parsley, garlic, onion, celery, or tomatoes, *but they must be strained* to remove vegetables; they may, however, be thickened with flour, fine oatmeal, arrowroot, or revalenta, or eaten with dry toast, torrefied bread, zwiebach, or plain biscuit. The light kinds of fish are also permissible to most patients (sole, plaice, whiting, and fresh haddock); also sweetbread and tripe. Chicken panada or soufflé is serviceable. Beef or mutton should be scraped and eaten raw; it can be taken in aspic jelly or port wine. Raw-beef juice is very good, and although strong soups and beef-tea are injurious, Brand's essence, Valentine's meat juice, Mosquera's beef jelly, and similar preparations are serviceable. Some patients may be allowed a small slice of tender, underdone beef or mutton, providing they remove the skin and fibrous portions. "Fletcherism" is useful. Bread must be stale and good, the crust should be avoided. The crumb of good stale bread crumbles into bits when rubbed between the finger and thumb. If it makes "pills," it should be rejected. Dry toast, torrefied bread, and zwiebach may be eaten. Biscuits or crackers which break into a powder are permissible, providing they are well masticated. Sponge cakes, Madeira cakes (without peel or currants), finger biscuits, Marie biscuits, etc., are allowable. Butter may be taken in moderation. Amongst vegetables we may allow potatoes (boiled or steamed), spinach, vegetable marrow, and a few tender kidney beans. Peas, cabbage, cauliflower, and tomatoes may also be eaten if they are passed through a sieve. In most cases the patient may have *cooked* apples, plums, damsons, peaches, cherries; *raw* oranges, plums, cherries, and bananas. Grapes must be freed from the skins and stones. Strawberries, raspberries, gooseberries, and currants can only be allowed when they have been passed through a sieve; they can then be eaten alone or with sugar and cream. Apple jelly, black-currant jelly, quince jelly, or guava jelly may be eaten with bread-and-butter. Honey and golden syrup are not injurious, but they sometimes have a laxative effect. The same remark applies to prunes and rhubarb.

The amount of fluids consumed should not be excessive. Perhaps it may advantageously be reduced to 2 pints, or, when the diet consists largely of milk, to 3 pints. Cocoa may be taken freely. Acorn coffee and leguminose cocoa are recommended by many people. Coffee is occasionally laxative. China tea may be

used. A little diluted spirit, such as brandy or sloe gin, may be taken. Red wine is good, and sloe wine or whortleberry wine is specially recommended. There is little doubt that most cases of long-continued diarrhœa are benefited by a diet consisting largely of proteins, and if it is decided to give this treatment a trial, some such diet as the following may be recommended:

Breakfast.—Cocoa, acorn coffee, or leguminose cocoa, two eggs, and a piece of dry toast.

11 *a.m.*—Kephir, koumiss, or yaourte, with a cracker or biscuit.

Midday.—Sole, plaice, or other light fish; scraped meat, scraped tongue, sweetbread, or chicken soufflé, vegetable purée, or vegetable marrow; custard, jelly, or strawberries, raspberries, or currants passed through a sieve; 3 or 4 ounces of red wine.

4 *p.m.*—China tea, dry toast and butter, one egg.

7 *p.m.*—The same as at midday.

Bedtime.—Koumiss or kephir, zweibach or cracker.

Chronic Tropical Diarrhœa, Hill Diarrhœa.—Tropical diarrhœa is attended by symptoms of disordered digestion, malnutrition, and progressive emaciation. Thin says the whole alimentary canal, and particularly the small intestine, becomes atrophied; but notwithstanding the general atrophy, there is a true sclerosis of the submucosa due to a development of the connective tissue, which leads to a degeneration of the glands and follicles. He believes the cause to be a specific poison which finds its best soil for development in the ileum. It alters the secretion of the mucosa and allows the food to retain its acidity, whence the dyspepsia, malnutrition, and acid stools. It destroys the colouring matter of the bile, and causes anæmia. The disease begins with *psilosis linguæ*, which causes discomfort in the mouth and throat and difficulty in swallowing. In its fully developed condition it gives rise to **sprue** or the white flux. The activity of the poison is increased by the nature of the intestinal contents. It develops freely in farinaceous and animal foods, but does not appear to grow in milk. Milk, however, is not the only substance in which it will not thrive, for it does not live on the juice of strawberries. Thin therefore recommends a milk diet, but he permits the consumption of strawberries to the extent of 2 or 3 pounds a day. Strawberries should not be taken in place of food, but between meals, and they may be taken with a little cream. They are usually borne well, and are distinctly curative. Thin considers their effect arises from the inability of the poison to live in them, and is not due to the mechanical effect of the seeds, and a diet of strawberries and milk will starve it out. It is possible that other fruits may have a similar effect, especially medlars. The milk should be taken through a quill or glass tube, or sipped with a spoon, in sufficient quantity to support the body, and, if possible, improve the nutrition (3 to 4 pints a day), and it should be warm and made alkaline by the addition of 6 to 10 grains of sodium or potassium bicarbonate, or lime-water for children. "All milk and only milk" appears to be the safest cure for natives

who do not take meat; but meat diet gives very satisfactory results in many cases. The mouth and teeth should be cleaned with an antiseptic wash after each meal.

Cantlie considers the acrid vegetable oils used in tropical countries by the Chinese cooks is a serious source of irritation to the mucous membrane, and aggravates sprue. He discarded milk because relapses were frequent, and prescribed meat diet, which he considers more satisfactory. He prescribes first of all a diet consisting of raw-meat juice, freshly made beef essence, raw-meat sandwiches, scraped beef, and plain jelly, the patient being fed every fifteen to thirty minutes. As strength increases the food is given at longer intervals and larger quantities. At the end of a week's treatment the patient is given 4 or 5 ounces of beef, minced in a machine, three times a day. About this time also the minced beef should be rapidly heated over a bright fire. Between the meals, and during the night, the patient is allowed plain jelly or calves'-foot jelly *ad libitum*. As a beverage hot water is allowed, also toast-water, China tea, and rice tea, the latter being made by pouring boiling water over roasted rice. The white of an egg can be mixed with the minced meat. About the tenth to fourteenth day the patient is allowed a slice of beef or mutton from any joint, underdone roast beef being the best. Boiled chicken or pigeon, and easily digested fish, are also allowed. Rice, boiled and steamed until dry, is allowed quite early in the treatment; but it is a long time before milk puddings are added to the list. Pulled bread, and bread cut into thin slices and baked in an oven until it is dry and crisp, are allowed after two or three weeks. The first vegetables allowed should be spinach, seakale, vegetable marrow, and boiled celery. Strawberries are allowed to be eaten abundantly between the meals. In this way the patient gradually returns to an ordinary mixed diet, and its effect is seen by an alteration of the colour and appearance of the fæces. With a milk diet the stool becomes solid, but it has scarcely the odour or appearance of fæces. The meat diet, on the other hand, brings down a dark-coloured bilious motion; the digestive organs in general become more active and their functions re-established; the liver especially is called upon, and it increases rapidly in size, and normal activity results. In combination with this treatment, physiological rest is necessary. The patient should remain in bed until vegetables can be added to the diet. Manson considers a milk diet is the best to begin treatment with, but it should not be slavishly adhered to; and the use of strawberries, apples, and bananas, is of considerable value. Thin also agrees that there is a stage in the treatment when milk diet is no longer required, when meat is borne well and causes immediate improvement. But this stage is when the specific diseased condition no longer exists, and its sequelæ only remain. In the early stages, he insists, milk is the best food; but when the right time arrives, which is found by experiment, meat should be added to the food, and the diet gradually built up, as in the treatment of ulcer of the stomach.

The use of various fruits has been recommended in the treatment of chronic diarrhœa Mercier[1] strongly recommends **medlars** in the cure of all cases of chronic enteritis, providing there is no acute dysentery. It is to be observed, however, that he gives them with 3½ pints of milk in twenty-four hours. He prescribes ½ pound of medlars a day; the fruit should not be soft (over-ripe), should be peeled, and the stones taken out. If an attack of dysentery intervene, the medlars should be stopped, and resumed again when it passes off. The results are said to be speedy and constant. The fruit never causes constipation. As the stools become normal, he adds in succession to the diet raw eggs, cream of rice, sweetbread, light fish, brains, chicken, beef-steak, and bread, milk remaining as a beverage. The medlar season lasts only from November to January. The fruit can be preserved, but it is not so beneficial as fresh fruit Mercier recommends the following mode of preservation: Medlars 1 kilo, sugar 800 grammes, water ½ litre; put them into bottles, boil them, and seal them hermetically.

Among alcoholic beverages red wines, Hungarian, old port, sloe wine, sloe gin, whortleberry wine, barberry wine are recommended; and toddy made from the fermented juice of the cocoanut palm is said to be a specific for chronic diarrhœa and dysentery.

Diarrhœa in Infants and Children.

The causes of diarrhœa in children are autogenetic or heterogenetic: (1) *Autogenetic :* Gastro-enteric catarrh (acute and chronic), intestinal fermentation, toxæmia. (2) *Heterogenetic :* Mechanical irritation, nervous influences, drugs, etc., acting through the milk; improper feeding; bacterial infection.

While agreeing with the infective nature of many forms of diarrhœa, too much stress cannot be laid on the part played by improper feeding. Breast-fed infants seldom suffer from diarrhœa. It occurs chiefly in bottle-fed children or in those recently weaned. It may arise from an excess of casein in the food or an inability to digest it. The curd acts as a foreign body, setting up diarrhœa by mechanical irritation; or it undergoes putrefactive decomposition, and gives rise to a toxæmia, of which the diarrhœa is a symptom. It may arise from an excess of carbohydrates, especially *maltose* and the malted foods of commerce. It may arise from an excess of fat, especially the fat of cow's milk. The scientific basis of the requirement for plenty of fat in the child's food is beyond dispute. But it must be digestible fat, that of human milk when possible. The food of infants from birth to six months should contain 4·0 per cent. of fat, from six to nine months 4·5 per cent., from nine to twelve months 4·0 per cent., and from twelve months onwards 3·5 per cent. It is evident that diluted cow's milk does not contain the proportion required. We therefore recommend the use of "top-milk," cream, and other humanized milk mixtures.

[1] *Practitioner*, 1907, ii. 570.

The additional fat increases the weight of the child, improves the nervous system, and the blood-making cells in the marrow of the bones. It has the further effect of preventing the aggregation of casein into large masses of curd, and rendering the milk more easily digested. But occasionally infants cannot digest foods containing more than 1 per cent. of fat from cow's milk. This is especially the case when the additional fat consists of "separator cream." It gives rise to indigestion, fat-diarrhœa, acidosis, and convulsions. The inability to digest fat results in enfeebled vitality; the enfeebled vitality causes a lessening of the oxidative processes in the tissues. The disturbance of the digestive processes leads to the formation of oxybutyric acid, which causes an acid auto-intoxication (*acidosis*), and secondarily, an increased destruction of protein to supply energy, while the imperfect nitrogenous metabolism leads to the production and excretion of ammonia in the urine. Fat is necessary to the organism, but it must be digestible fat. The normal fæces of the breast-fed child contain some fat. But the fat of cow's milk, consisting of much larger globules, is less easily digested than that of human milk. The difference in the size of the fat globules of human milk and milk fresh from the cow is very great. But the difference between the fat globules in human milk and in "*separator cream*" is far greater. The act of centrifugalizing the milk, in order to separate the cream sold in shops, breaks up many of the milk globules; they become aggregated together, and form tiny particles of butter. The emulsion is more or less destroyed. Many children cannot digest such cream, and it must be substituted by "gravity cream" or that collected by *skimming* the milk set aside for six or eight hours.

Mechanical irritation is the cause of diarrhœa resulting from attempts to feed young children with bread, oatmeal, barley flour, and proprietary foods containing much starch. In older children diarrhœa often follows the consumption of partly cooked cereals, fruit containing seeds (strawberries, currants, gooseberries), dried fruits (figs, cake containing carraway seeds, raisins, or currants), green vegetables (boiled cabbage, cauliflower, carrot, turnip, celery, lettuce, watercress), all of which act virtually as foreign bodies, irritate the mucous membrane, cause an increased peristalsis, and sometimes a catarrhal inflammation of the mucosa.

The effect of drugs need scarcely be mentioned, except to remind the reader that many drugs are excreted by the mammary gland, and therefore aperients may affect the nursing infant through the milk. In the same way the consumption of cabbage, cauliflower, pickles, prunes, and other substances by the mother will affect the nursing child, and may cause diarrhœa.

Catarrhal diarrhœa is the ordinary looseness of the bowels which affects children in early life, especially during dentition. Nervous influences may excite diarrhœa. This sometimes happens when the surface of the body gets chilled, or as a result of the depression caused by excessive heat, fatigue, exhaustion, fear, excitement.

Coldness of the feet is a common cause of stomach ache and looseness of the bowels in infants. Many instances of diarrhœa are characterized by an exaggerated peristalsis. In such a case the consumption of food, taking a chill, a fright, or excitement, will immediately start a violent peristalsis, in consequence of which the food is hurried rapidly along the alimentary canal, and undigested materials appear in the fæces. The mother often says of such cases: "My child's food passes through it as soon as it is eaten." This form is called *lienteric diarrhœa.* Even older children may be troubled with this exaggerated peristalsis, which, when started by eating, frequently causes the child to hurry away from the table, owing to the sharp pain and rapid action of the bowels.

Diarrhœa due to bacterial influences is most prevalent in the summer-time, whence it is called "summer diarrhœa." But the predisposing causes of such diarrhœa are exceedingly important: they are the age and constitution of the child, improper feeding, and bad environment. Given one or more of these predisposing causes, a slight exciting cause will start the diarrhœa. One of the most striking features is the prevalence of the disease in hot weather. An epidemic does not begin until the mean temperature of the atmosphere is 60° to 61° F., and remains so for four to eight days. The epidemic begins towards the end of July, is in full force throughout August, and lasts well into the third week of September, the mortality being highest during the first weeks of the epidemic, because few delicate infants can stand the first month of great heat. But heat alone is not sufficient to give rise to an epidemic. The disease is of infectious origin. The temperature, which is necessary for the production of diarrhœa, is the same as that most suitable for the activity of the bacteria. The disease is most common among recently weaned children and those fed wholly or partly on cow's milk. Cow's milk ordinarily contains an enormous number of bacteria, increasing in proportion to the time which has elapsed since milking, and the temperature at which it is kept. But the infection causing summer diarrhœa may be of two kinds:

1. *Autogenetic,* resulting from the normal bacterial flora of the intestines becoming pathogenic. The change in the action of the bacteria and the nature of the products is dependent upon some alteration in the *conditions* in the alimentary canal. The result of the change, however, is the production of a severe gastro-enteric intoxication, which is not always distinguishable by the clinical signs from acute indigestion. As a rule, however, the temperature is higher, the nervous prostration greater, the stools more liquid and offensive.

2. The *heterogenetic* form of summer diarrhœa is far more fatal. It is due to the introduction of bacteria from without, usually in the food. The bacteria are Streptococci, Staphylococci, *Enteritidis sporogenes,* colon bacillus, the proteus, the bacillus of Shiga, and *Bacillus cyanogenus.* There are several clinical types of the disease, but they probably depend less on the kind of bacteria than on other

conditions, such as the state of the mucous membrane or the resisting power of the child's organism. The term *cholera infantum* is only a generic name, and not a very satisfactory one. The important symptoms are due to the absorption of toxins, produced by the bacteria, which create a profound impression on the heart, nerve centres, and especially the vasomotor centres. The vomiting and purging may be due to toxins or an effort of nature to rid the organism of their presence. The high temperature is due to a disturbance of the heat centre, and is a characteristic of many toxic conditions. The loss of elasticity of the skin is likewise a symptom of the profound toxæmia, and is a grave sign.

The *Treatment* is both prophylactic and remedial. Prophylactic measures consist of breast-feeding and avoiding weaning in the summer-time. Bottle-fed children should have pure milk made into mixtures of a proper composition and suited to their age. The milk should be filtered through a layer of cotton-wool to remove bacteria: 80 per cent. of the bacteria in milk can be removed by this means. Improper foods must be avoided, especially an excess of casein and malted foods. Overfeeding must be avoided as carefully as improper feeding. Children become thirsty in hot weather, but they should not be given more food on that account. They should be given plain boiled water or distilled water to quench their thirst. There are two reasons why water should be boiled or distilled for young children: The first is for the destruction of bacteria, and boiling or distilling the water on this account is always necessary. The second reason is equally important. Hard water contains salts of lime and magnesia, which combine with fatty acids in the alimentary canal, and form insoluble soaps, thereby causing a loss of valuable fat from the food. Infants' food seldom contains too much fat for healthy children, often not enough. If, therefore, any of the fat can be saved by eliminating unnecessary salts of lime and magnesia, a useful purpose will be served by giving only boiled or distilled water. Other prophylactic measures consist of scrupulous cleanliness of the napkins and clothing, freedom from dust in the house (which consists chiefly of organic matters), protection from flies, and sudden changes of temperature. A thin flannel or woollen (not flannelette) garment should be worn next the skin to protect the abdomen from chills. The feet should be covered. Fresh air and sunlight are essential.

The remedial measures consist of relief from the sickness and purging, removal of nervous depression and toxic symptoms, and reduction of the temperature. The vomiting may be relieved by lime-water, barley-water, milk of magnesia, washing out and resting the stomach. Drugs may assist by soothing the irritable condition of the mucous membrane. Ingluvin, calomel, or the hypodermic injection of small doses of morphine and atropine are useful. Astringents are of little value for checking the purging in severe cases, especially while the toxæmia and high temperature last. Should the purging continue after the temperature has fallen to

nearly normal, astringents will then be more useful. During the acute phase of the disease an attempt must be made to stop the septic process by other means. The best way of eliminating the bacteria probably consists of abstinence from food, which supplies the nutritive media on which they flourish. The purging is an effort of nature to rid the system of the toxic substances. Hence the administration of purgatives and lavage of the colon will assist nature in her design. At the same time various drugs of an antiseptic character may be given by the mouth. Colon lavage is one of the best means of bringing down the temperature.

The dietary is of extreme importance. Breast-fed infants should be kept from the breast so long as vomiting occurs. They may be fed with a little albumin-water, barley-water, or whey; and stimulants if they seem desirable. After twenty-four hours' rest of the stomach it is usually safe to resume breast-feeding gradually, at first allowing the child to suck for only two or three minutes at a time, by which means he will get one-fifth to one-fourth the usual amount of milk. He should be fed with albumin-water, whey, or albumin-water with a little meat juice, every two hours, until a considerable progress is made towards recovery. In these and other children the depression must be fought by the administration of brandy, champagne, camphor-water, musk, or ether. If stimulants are rejected when given by the mouth, small doses of strychnine and ether may be given hypodermically, or saline solution may be slowly injected into the subcutaneous tissues of the abdomen or buttocks.

In the case of hand-fed children all ordinary foods must be stopped until the vomiting ceases, merely giving a little plain water or barley-water. When these are retained, begin to feed cautiously with egg-albumin and lemon-water, whey, white wine whey, butter-milk, chicken broth, or veal broth, a teaspoonful every quarter of an hour. We are cautioned by various authorities against the use of meat extracts, because they tend to increase diarrhœa. But there are cases where the stimulating effect of xanthin and creatin is valuable; and when a child does not react with egg-albumin or whey, no harm can be done, and possibly good may result from administering Valentine's meat juice, Bovinine, Brand's essence of beef, or Hipi in small doses. Albumin-water is insipid, but a few drops of Bovinine, Valentine's meat juice, or Hipi, will improve the flavour, and give to it stimulating properties which are lacking. Children of four or five months' old may have a little panopepton or beef jelly (Mosquera's). Children from this age onwards may also have starch emulsion (arrowroot being preferable) with egg-albumin. Starch emulsion is useful by checking protein decomposition and a persistent diarrhœa.

A year old child may also have, during the acute stage, whey and cream, veal broth and rusk, Mellin's food and barley-water, every alternate meal. Older children may have arrowroot and white of egg, whey and white of egg, white of egg and lemon-water,

chicken broth, veal broth or mutton broth, a little black-currant or whortleberry jelly, rusks, dry toast, fermented milk or koumiss, the return to ordinary diet being gradual.

As soon as the acute stage passes off, which is known by the cessation of vomiting, moderation of the diarrhœa, and reduction of the temperature, infants may have mixtures consisting of whey and cream, buttermilk and cream, or egg mixtures. Children more than four years old may have Mellin's food and barley-water or other dextrinized foods: whey and cream, buttermilk and cream, egg mixtures, peptonized milk, condensed milk and water 1 in 8 **(temporarily)**, fermented cow's milk, yaourte, or koumiss. In all these substances the protein differs in its physical condition from the casein in ordinary cow's milk. Whey can easily be prepared by the addition of liquid rennet, junket tablet, or powder, to warm milk. A pint of milk yields 12 to 14 ounces of whey. Buttermilk can be obtained from a dairy. Yaourte or leben is prepared by the lactic ferment, which is sold in various forms by all chemists. Ordinary fermented milk, usually the nearest approach to koumiss, is prepared with ordinary yeast and entire or skim milk, according as much or little fat in the food is desired. The table on the opposite page shows the composition of these substances and of mixtures prepared from them.

When the diarrhœa passes off, we must consider, if the food has been at fault, how best to correct the error. *If the fat has been in excess* of the child's ability to digest or metabolize it, owing to defective assimilation or oxidation in the tissues, the proportion, must be reduced. Cream mixtures should be avoided in such cases The child should be fed, temporarily at least, on whey and white of egg (egg mixtures, No. 1 or 3), condensed milk and whey, Mellin's food and whey or milk, extract of malt and milk, gradually increasing the strength of the food and adding *gravity* cream, but not separator cream, as the functions of digestion and metabolism improve. If *malted foods* have caused diarrhœa, avoid them and malt extracts also. *If the casein has been in excess* of the child's digestive capacity, give egg mixtures, cream mixtures, or whey and cream mixtures, wherein the casein is changed and rendered more easily digested. In cream, whey, and buttermilk the casein coagulates in fine flocculi. Even in condensed milk and water the casein coagulates in smaller curds than in ordinary milk. If, however, the poverty of the family is such that the child must be fed upon diluted milk, let it be treated so that the casein cannot form large or hard curds. The addition of 1 grain of sodium citrate to each ounce of milk will prevent the formation of curds by the precipitation of lime, a chemical action resulting in the formation of calcium citrate and phosphate of soda taking place. The addition of a teaspoonful of extract of malt to $\frac{1}{4}$ pint of warm milk will, in ten minutes, alter the casein so that it will be precipitated in fine tufts or flocculi little larger than those of human milk. When obtainable, gravity cream can be added to this mixture to raise

the percentage of fat The chapter on Infant Feeding should be read, and the milk ought to be more or less humanized according to the directions given therein.

Composition of Mixtures.	Nutrients per Cent.		
	Protein.	Fat.	Sugar.
Whey (casein 0·25, albumin and globulin 0·75, per cent.)	1·00	1·10	4·50
1. Whey 19 parts, cream 1 part	1·00	1·80	4·10
2. ,, 10 ,, ,, 1 ,, ...	1·10	2·80	4·90
3. ,, 5 ,, ,, 1 ,, ...	1·25	4·00	4·80
Buttermilk (casein 2·5, albumin and globulin 1·3, per cent.)	3·80	1·28	3·38
1. Buttermilk 10, water 10, sugar 1, cream 1	1·90	1·40	6·60
2. ,, 10, ,, 10 ,, 1 ,, 2	2·00	2·10	6·50
3. ,, 10, ,, 10 ,, 1 ,, 3	2·10	2·80	6·30
Condensed sweetened milk and water, 1 in 8 ..	1·25	1·31	6·40
Peptonized milk (casein 1·84, peptones 1·76, per cent.)	3·60	4·00	4·50
Yaourte or leben (milk fermented by lactic acid ferments, casein 3·25, peptones 0·35, per cent.)	3·60	3·50	2·00
Koumiss (yeast fermentation): 1. Entire milk: Casein 2·34, albumin 0·5, peptones 0·26	3·20	1·90	2·50
2. Skim milk: Casein 2·5, albumin 0·5, peptones 0·35	3·35	0·80	2·60
Egg Mixtures: 1. White of one egg; whey, 5 ounces, sugar, ⅛ ounce	3·10	1·04	5·30
2. One raw egg; whey, 7 ounces; sugar, ¼ ounce	3·24	2·90	6·80
3. White of one egg; half yolk of one egg, sugar, ½ ounce; water, 5 ounces; raw-meat juice, ⅞ ounce	3·50	1·29	7·00
Chicken broth, contains 2 per cent. extractives, besides	3·60	0·20	—
Veal broth, contains 2 per cent. extractives and gelatin, besides	2·70	0·30	—
Home-made beef juice contains 3 per cent. extractives, besides	2·90	0·60	—

Constipation.

Constipation is a consequence of civilization, and is largely dependent upon the composition and preparation of the food. Primitive man ate roots, leaves, seeds, and fruit, and animal food, with very little preparation. In uncivilized communities to-day the food is eaten after very little preparation and very little cooking, so that the indigestible residue is a mechanical stimulus to peristaltic action. Constipation is a necessary sequence of the art of preparing and cooking the food. The coarse meal resulting from

primitive modes of grinding grain and roots is very different from the entire wheatmeal of the modern miller; and entire wheatmeal contains much more cellulose than the fine white flour of the steel roller mill. The latter is almost devoid of cellulose, and the fine starch is almost entirely transformed into sugar by the alimentary enzymes, and leaves little residue behind it. Similarly, the vegetables, fruits, and seeds consumed in the present age by civilized people have been developed by art to such an extent that they contain much less woody fibre than similar articles grown in the early days of cultivation; in fact, the influence of man upon all kinds of foodstuffs tends to their refinement. The bulk of the food is reduced by the removal of coarse material, and it contains comparatively little residue. Some persons who have a deficient appetite eat very little vegetable food, and consequently the stimulus to peristalsis is absent. Moreover, the food consumed may be too soft, as a diet consisting of bread-and-butter, tea, and farinaceous foods. Hence the poor, who live largely on bread, butter, potatoes, etc., may suffer from constipation as much as the rich whose diet consists largely of tender meat, game, and other foods of a high quality and concentration. In addition to the mechanical stimulus of the food, there should be a chemical stimulus arising from its composition. Certain sugars, neutral salts, gases, by their presence stimulate secretion or peristalsis or both, and their absence tends to constipation.

Another cause of constipation arises from the dryness of the fæces. This may be due to various causes—*e.g.*, drinking too little fluids. It has been shown that about 4 pints of water are eliminated from the body daily, and in ordinary circumstances part of this goes out by the bowels. But many people drink as little as ½ or ¾ pint of fluids daily, which is not sufficient to keep the fæces soft. As the contents of the alimentary canal pass along its course, more and more liquid is absorbed, and the longer the residuum remains in contact with its walls, the drier it becomes. If a healthy individual, who is accustomed to a daily evacuation, is involuntarily compelled to omit the evacuation for twenty-four hours, the fæces remaining in the colon become drier and firmer, and form scybala, or become pressed into a hard mass of less bulk than the usual fæces from a single day's food. Extraordinary exercise on the part of the subject may lead to constipation by causing undue evaporation of moisture from the skin, thereby concentrating the liquids of the body. Excessive diuresis has the same effect—*e.g.*, in diabetes. The dryness of the fæces may arise from some constituent of the food. Milk is apt to produce such fæces when it is taken alone and in large quantities, because large masses of curd become matted together and resist the action of enzymes. When milk is combined with farinaceous foods, it does not form such large curds, because of the interposition of starch granules, and such curds readily fall to pieces and become digested. The consumption of very hard water causes dry fæces, because the lime inhibits the

action of involuntary muscular fibres, and thereby causes the food to remain longer in contact with the mucous membrane, and moisture to be absorbed.

There are many other causes of constipation Atony of the bowels or diminution of the peristaltic and expulsive power is a common cause of the ailment. There may be a disproportion in the development of the muscular system. As Brunton points out, the voluntary muscles may be well developed, but the involuntary muscles less developed than in a normal individual. The intestines may become weakened by disease—*e.g.*, fever, chronic intestinal catarrh, peritonitis, and affections of the nervous mechanism. Constipation may arise from weakness of the abdominal muscles, as a consequence of pregnancy, tumours, accumulation of fat within the abdomen. The muscles may become weak from malnutrition, insufficient food, want of exercise, or sedentary habits. Diminution of expulsive power may be due to cardiac defects, or the existence of fissure of the anus, piles, fistula, or pelvic disease. Portal congestion arising from cardiac or hepatic disease is apt to cause constipation from venous congestion, catarrh, hæmorrhoids, etc.

Habit has a powerful influence upon the evacuation of the bowels. The introduction of food into the stomach starts a peristaltic action, which spreads all along the alimentary canal, and is the cause of the matutinal "call of nature." An evacuation, or tendency to it, occurs in many persons after each meal. The morning evacuation should be encouraged by all people, and there are many persons who are much better in health when an evacuation occurs after the midday meal also. An habitual disregard of this "call of nature" is an exceedingly common cause of constipation. There are occasions when it is impossible to respond to it, and such neglect is usually followed by discomfort, and perhaps headache for the rest of the day.

Peristalsis is stimulated by the presence of food, particularly by the indigestible residue of meat, vegetable fibre, cellulose, sugar, organic acids, and salts. Peptones stimulate it feebly, oils more strongly, and gases—especially CH_4 and SH_2—even more powerfully. Peristalsis is a steady muscular movement, impalpable, unrecognizable, always going on, and capable of becoming a terrific force. But it is a matter of "shifts," being accelerated by a meal, while abstention from food tends to stasis or constipation. A regular defæcation can only be insured by the presence in the colon of soft pultaceous fæces permeated by gas. Defæcation is also promoted by muscular exercise and hindered by rest.

Constipation may be obstructive or non-obstructive. The latter is due to atonic and spastic conditions. The atonic form is due to many causes previously detailed, but especially neglect, anal fissure, hæmorrhoids, pelvic diseases, loss of power of the voluntary or involuntary muscles, visceroptosis, etc. Spastic constipation or chronic spasm of the colon is associated with a neurosis dependent on toxæmia. Hertz defines constipation as the retention of fæces

more than forty-eight hours, and divides cases into (1) retention of fæces above the iliac crest, (2) retention below the iliac crest—*i.e.*, in the sigmoid flexure and rectum. Arbuthnot Lane speaks of constipation as chronic intestinal stasis, and he attributes it chiefly to non-inflammatory peritoneal adhesions produced mainly by the erect posture of man. The cæcum and ascending colon become dilated and adherent to the posterior wall of the abdomen; meanwhile the transverse colon tends to form a loop, the splenic flexure and descending colon become fixed to the posterior wall of the abdomen; the sigmoid flexure is shortened, its lumen narrowed, its muscular coats wasted; and the rectum becomes elongated, dilated, and hypertrophied. The stomach dilates, the lumen of the small intestine narrows, its muscular coats atrophy, and various loops become adherent. These mechanical impediments cause coprostasis, and chronic toxæmia arises from it. The chief seat of toxic absorption is the colon, and Lane's remedy is removal or exclusion of the colon by anastomosing the ileum with the sigmoid flexure or rectum. Colectomy has been performed many times without danger to life, and in many instances with benefit. But every case of constipation does not require such drastic treatment, and some authorities urge it is only necessary in Hirschsprung's disease. Goodhart opposes colectomy. He objects to the theory that the colon is a poison-bag and ought to be removed. It performs important functions of absorption and elimination. The latter is an active casting out of materials which clog the machinery. The system cannot do without this cleansing action, and the colon ought not to be removed.

Treatment.—In all cases of constipation it would undoubtedly be improper to consider the necessity for operative treatment until a good chance had been given to improve the condition by means of medicine, food, and other measures. Our object now is to discuss the dietetic principles of treatment.

In **atony of the bowels** the diet should be such as will stimulate peristalsis—a cellulose diet. The bread should consist of one of the numerous varieties of brown bread, or wholemeal bread, which contain far more cellulose than the fine white bread of the modern roller mill. Oatmeal should be taken for breakfast or supper, and coarse oatmeal or miller's pride is better than fine oatmeal, rolled oats, and many other breakfast foods. Oat cakes, Yorkshire parkin, oat biscuits, and so forth are especially valuable. Rye bread and buckwheat cakes are other valuable foods for the constipated subject. Dried peas, beans, and lentils, leave a large residue, and provide material to stimulate the muscular coat of the bowels to activity. Currant bread, sultana cakes, ginger-bread, ginger-nuts, French parkin; treacle, honey, maple syrup, jam, and especially orange marmalade, are stimulants to peristalsis.

The patient should be encouraged to eat plenty of cabbage, savoy, Brussels sprouts, cauliflower, spinach, turnips, ruta baga, carrots, parsnips, artichokes, sweet potatoes, potatoes, boiled onions,

and boiled celery. Kidney or string beans, green peas, vegetable marrow, and squash are permissible, but of less value, because they contain less cellulose. Salads consisting of lettuce, endive, tomato, cucumber, radishes, beetroot, watercress, mustard and cress, sorrel, dandelion, and other green vegetables, will also assist, especially when salad oil is used in the dressing. Puddings should be of the " heavy " kind, such as boiled dumplings, suet puddings, boiled currant or jam puddings, boiled fruit puddings, fig pudding, Yorkshire pudding with treacle or marmalade, pancakes cooked in fat. Stewed prunes, figs, rhubarb, pears, plums, apricots; baked apples; currants, gooseberries, and cranberries; in fact, all fruits containing seeds will stimulate peristalsis. Dessert may consist of practically any raw fruit, the organic acids being a stimulant to peristalsis: apples, pears, plums, apricots, peaches, gooseberries, currants, strawberries, oranges, and grapes. Figs and dates act largely by virtue of the contained sugars. The " grape cure " is recommended, and is of great value in many cases.

The animal foods may consist of ordinary meat, poultry, game, or fish, but the amount should be rather small, taken at the midday meal only, and the fatter it is the better it will suit the complaint. Fatty foods as a rule are very good, unless they induce " biliousness "—fat ham and bacon for breakfast and supper, butter, cream, and cream cheese. Boiled eggs or hard-boiled eggs are considered constipating, but buttered eggs or scrambled eggs are laxative by reason of the fat used in cooking. Boiled eggs are not constipating to everybody. There are some people who are purged by the yolk of one egg. Soup, broth, and meat extracts are useful by promoting secretion. Lactic acid favours the normal functions of the bowels, and therefore kephir, koumiss, and other sour-milk preparations are good foods.

Very few of the ordinary articles of food need be forbidden, excepting those which leave very little residue. Cheese is one of these articles. Milk should never be taken in large quantity, but the small amount required for tea or coffee need not be forbidden. Rice, sago, tapioca, arrowroot, and cornflour leave little residue; some of them are almost completely, absorbed in the small intestines, and therefore they do not leave enough fæces to stimulate peristalsis. A few spoonfuls of any ordinary milk pudding may be allowed, especially if it is eaten with stewed prunes, figs, marmalade, or other cooked fruit, or followed by some *raw* fruit. Nuts are generally forbidden. Potted meats, fish pastes, and so forth, are useless; but *foie gras* and even caviar may be taken if they do not cause biliousness. All concentrated foods—*e.g.*, milk powders and meat powders—are said to induce constipation, because they leave practically nothing behind them.

Beverages.—Constipated people should be encouraged to drink plenty of fluids, especially such as have no effect in counteracting peristalsis. Ordinary water is one of the best beverages, unless it contains an excess of lime. It increases the fluidity of the fæces.

When taken cold, it stimulates peristalsis, and is especially valuable if taken before breakfast. It may be taken plain or aerated, and sweetened or acidified as desired. Some persons complain that cold water causes dyspepsia, and they may drink *hot* water. Many fruit juices or syrups can be added to the water, especially rhubarb juice, gooseberry juice, currant juice, plum juice, fig syrup, orange juice, lemon juice, grape juice. Distilled water may be taken if it is preferred. Salutaris may be had plain or aerated. The special waters such as Perrier, Apollinaris, Vals, Vichy, Selters, St. Galmier, Leamington, Bath, Malvern, Bourne, and others, simply supply water with a little alkali; others are more alkaline, such as Saratoga-vichy, Kroenquelle, and Kissingen; and others have mild aperient properties, as the Carlsbad water.

The juices of the grape, apple, pear, and gooseberry form a good beverage, and their organic acids stimulate peristalsis. There are various "grape juices" on the market—*e.g.*, Vin de Vie. Cider and perry, especially "rough cider," is useful. Mead or fermented solution of honey is likewise beneficial when it is not too alcoholic. New ale, bitter beer, porter, and lager beer may be taken, and are somewhat laxative. Whey, buttermilk, and koumiss are recommended partly because of the lactic acid they contain. Linseed tea, barley-water, and oatmeal-water all have a tendency to relax the bowels. The morning cup of coffee is laxative to many persons; but tea and cocoa have the opposite tendency, although China tea and cocoa made from concentrated essences are permissible. Red wines and sherry are more or less constipating, but a little white wine—*e.g.*, Moselle, Chablis, or Sauterne, may be allowed.

Spastic constipation, or chronic spasm of the colon, is very often associated with conditions that require different treatment from atonic constipation. It is necessary to avoid most of the foods which are really valuable in the former class of cases. It is proper to *forbid* brown bread, oatmeal, coarse fibrous vegetables, salads, raw fruit, and cooked fruits which contain seeds.

On the other hand, the food should be soft, bland, and unirritating, and may be more concentrated. Animal foods should be deprived of all skin, gristle, and fibrous tissue. Scraped meat, raw meat, and meat juice may be taken. Potted meat, minced tongue, and chicken are now useful. Green vegetables should be cooked and rubbed through a sieve, and only taken as a purée or consommé. Fruit should be deprived of skin and seeds; currants, gooseberries, strawberries, and raspberries should be broken down and passed through a sieve, and eaten with cream or cream cheese. Rice, sago, tapioca, arrowroot, and macaroni are preferable because of their bland and unirritating properties, and the small residue from them. Jelly of all kinds is useful. Jelly made of agar-agar is considered especially valuable. Fermented milk made with cultures of *B. acidi lactici* or the Bulgarian bacillus is allowable; koumiss and kephir are useful; cream, cream cheese, butter, eggs, boiled or poached, and milk powders, may be used. But it is,

above all things, necessary that the food should be nutritious and of a high calorie value.

Obstructive Constipation due to fibrous or malignant stricture also necessitates the use of a diet which will leave very little residue, and most of the foods prescribed for spastic constipation are permissible.

Agar-Agar in Constipation.—Schmidt found that the stools of constipated persons are more or less sterile, and attributed the inaction of the bowels to the absence of bacterial products, and especially the gases produced by them. He advocated the consumption of agar-agar as a culture medium for the bacteria. Mendel also considers agar-agar valuable in the treatment of constipation for other reasons. Agar-agar is obtained from a seaweed, and contains simple carbohydrates which are little affected by the digestive enzymes. Most of it is excreted unchanged, but it readily absorbs and retains water, thereby imparting a soft consistency to the fæces and preventing the formation of scybalous masses. Gompertz[1] prescribed it for thirty patients whose ages varied from fifteen to eighty-three years, who suffered from chronic constipation, and the majority of whom had never had a motion without medicine or enemata. The amount recommended is 15 grammes twice daily, the strips being ground into coarse meal, like modern uncooked breakfast foods, and eaten with milk or cream. Regulin is a preparation of agar-agar with a small amount of cascara In a few cases 15 grammes of agar-agar causes diarrhœal stools, but this can be modified by varying the quantity. Regular movements begin to occur after two or three days, the evacuations being increased in volume, well formed, and of dough-like consistency. It is recommended that the agar-agar be taken regularly for three months, but gradually reduced in quantity as the stools become normal and the activity of the bowels approaches regularity.

The treatment of constipation includes the cure of the cause, and the latter must be sought in every case. If it is a consequence of hyperchlorhydria, or other abnormal gastric condition, it should be treated as directed under that head. Hæmorrhoids, anal fissure, ulcers, and similar conditions must be cured. Pelvic diseases should have proper attention. Enteroptosis necessitates the use of a proper belt. Mechanical causes of constipation should be relieved. The formation of regular habits and the adoption of a correct posture during defæcation should be inculcated. Abdominal massage along the course of the colon is beneficial. The practice of Swedish and other muscular movements is valuable, and electricity is a useful aid in treatment, either the constant or faradic current being employed. If the constant current is used, one electrode, 6 or 8 inches square, should be placed over the lumbar region, and the other, consisting of a disc 2 or 3 inches in diameter, should be moved along the colon from right to left.

[1] *Amer. Jour. Med. Sci.*, October, 1909, and *Practitioner*, May, 1910.

Intestinal Catarrh and Colitis.

Acute catarrh of the small intestines (*enteritis*) is mostly attended by diarrhœa. The mucous coat is congested and swollen, large quantities of mucus are secreted, and epithelial cells are readily detached. The irritation of the mucous membrane causes increased peristalsis, and the passage of loose or liquid stools of a pale yellow or greenish colour, containing more or less solid matter, particles of undigested food, mucus, bacteria, detached portions of epithelium, and sometimes blood. A griping colicky pain occurs spasmodically, and sometimes vomiting. It usually subsides in a few days with the treatment detailed under the head of Diarrhœa.

Acute catarrh of the colon, called *simple colitis*, is a catarrhal inflammation similar to that of the small intestines. It may be primary or secondary. The primary form occurs most commonly in children, but it may affect adults, and is always due to micro-organisms, bacteria, amœbæ, infusoria, of which *B. enteritidis sporogenes* is always present. The main symptom is a sudden onset of diarrhœa, but blood and mucus are often present in large quantities. The movements are frequent; there may be tenesmus; much flatus is passed, and borborygmi or rumblings in the bowels may occur. Pain of a griping character occurs spasmodically, but between the paroxysms nothing is felt, although there is commonly much tenderness of the abdomen, especially along the course of the colon, and about the sigmoid flexure in particular. The case may be mild, and scarcely give rise to any increase of temperature, but severe cases are attended by fever and a soft running pulse.

Secondary catarrh of the colon may occur in connection with various diseases, especially in the course of Bright's disease or lardaceous degeneration, the stools being sanious and mucous. It occurs sometimes in septicæmia and pyæmia. It arises now and again in pneumonia, and may then be due to invasion by the pneumococcus. It may be due to direct irritation of the mucous membrane by *Oxyuria* and *Bilharzia*, or powerful irritants, such as arsenic and mercury, and occasionally as an extension of such disease in the stomach due to virulent poisons or mineral acids.

The diet in all these cases is that detailed under Diarrhœa or Dysentery. Milk, however, should be the chief food, and "milk, nothing but milk," until the diarrhœa ceases, blood is no longer evacuated, and well-formed stools are passed, is the rule given by many authorities. The quantity of milk given at a time should not be more than 2 or 3 ounces, diluted with lime or barley water, and the total amount from 3 to 4 pints daily. In severe cases the milk diet must be given for many weeks, and the return to ordinary diet must be gradual and by easy stages. When the acute symptoms pass off, Benger's or Savory and Moore's food, arrowroot, tapioca, rice-milk, junket, blanc-mange, then fish, tripe, sweetbread, chicken, may be gradually added.

Ulcerative Colitis.—The colon may become ulcerated in dysentery, enteric fever, tuberculosis, and malignant disease, but there is a special form of ulcerative colitis, to which reference is now made. It occurs in men and women, and gives rise to a group of definite symptoms, resulting in a very grave state of things and a high rate of mortality. It is always attended by pain, diarrhœa, bloody stools, and frequently by vomiting. As a general rule the first sign of being ill is a severe attack of abdominal pain, frequently occurring suddenly, of a griping character, very sharp and severe. The pain is not constant, but paroxysmal, the periods of attack varying from a few minutes to as many hours. It has no relation to the food. It is usually felt in the front of the abdomen, not always in the same spot, and may be accompanied by pain in the back, side, or chest. Tenderness is usually absent, unless it be along the colon. Diarrhœa is never absent. It may occur before the pain, but this is not usual, and it may alternate with constipation. The number of movements varies from two to twelve daily. Defæcation is attended by pain, but tenesmus and frequent desire to defæcate are not so common as in dysentery, neither do the stools resemble those of dysentery or cholera. They are nearly always foul, fluid, and dark-coloured. Blood is present in them, especially after a period of constipation, and it often forms a clot, like red-currant jelly. Mucus forming little transparent pellets is visible in the motion, and there may be shreds of mucous epithelium, which may be broken up or altered by mixture with the intestinal contents. Vomiting and nausea sometimes occur. Vomiting may be one of the earliest symptoms, but it is not constantly present. The cases vary in duration, but the patient always becomes seriously ill, wasted, debilitated, and anæmic. The tongue, at first coated with a dirty white fur, becomes dry and brown, or clean and red. Thirst becomes a prominent symptom, and is induced by the loss of fluids from the body. The pulse becomes feeble, hæmic murmurs arise, and the temperature ranges from 100° to 102° or 103° F. The mortality from ulcerative colitis is so high that it has been said that a recovery throws a doubt upon the nature of the illness. The patients usually die in a month or two from the beginning of the disease, death being preceded by a high temperature, severe diarrhœa, and profuse hæmorrhage.

The cause of ulcerative colitis is unknown. An attempt has been made to prove it is dysentery, but the clinical signs are not the same. Various micro-organisms have been found associated with it. *B. dysenteriæ* of Shiga have been found in the evacuations, but it has been shown that no hard-and-fast definition of this bacillus can be given. Dysentery is due to more than one organism, and Shiga's bacillus has been found in the diarrhœa of infants, while it is not the only bacillus found in ulcerative colitis.

The *Treatment* is exceedingly unsatisfactory, because so seldom successful. The food should consist of milk, junket, custard, blancmange, jelly, and predigested carbohydrates. Soup, broth, beef-

tea, and meat extracts should be avoided, and also fruit, vegetables, oatmeal, etc. Brandy may be given to the extent of 3 or 4 ounces a day. Red wine, and especially whortleberry wine, has been suggested. Rectal lavage with ½ to ¾ pint of boracic lotion, or a solution of potassium permanganate, or other antiseptic of a soothing character, may be used. Warm applications to the abdomen may be applied, and opium may be given internally.

Asylum dysentery, another form of colitis, gives rise to symptoms like ordinary dysentery—blood and mucus in the stools. The mortality is high; 50 per cent. of cases die. The diet should consist of milk, junket, custard, jelly, etc. The colon should be irrigated with an antiseptic lotion.

Chronic Intestinal Catarrh, Mucous Colitis, Membranous Colitis.—(1) Chronic catarrh of the intestinal canal occurs in a large number of persons who are the subjects of passive congestion arising from chronic bronchitis, emphysema, atony of the heart, and other forms of heart disease; likewise from chronic indigestion, chronic hyperæmia of the liver, portal congestion, and obstructive causes in general. Such patients may have diarrhœa or constipation, or one may alternate with the other. The masses of tough mucus which are formed hinder absorption and nutrition, and the patient becomes feeble and the general nutrition fails. Many of these cases are attended by the decomposition of food in the intestinal canal, with distension of the abdomen by gases or distressing flatulence, which impedes the breathing and still further obstructs the circulation. The general symptoms of catarrh of the alimentary canal are usually present. The motor and secreting functions of the stomach may or may not be affected, but there is usually a diminution of hydrochloric acid, although no general rule can be laid down. The abdomen generally may be tender on pressure, and it is usually more or less tender along the course of the colon. Constipation is the rule, but does not affect all cases. Catarrh of the small intestines may be attended with excessive secretion, loud gurgling, and rumbling in the abdomen, due to the movements of liquids and gases in that area. Such people may have diarrhœa, but constipation is not uncommon, because the fluids are absorbed in the lower part of the gut.

(2) When the catarrh affects chiefly the colon (*mucous or membranous colitis*), much mucus appears in the stools. In *mucous colitis*, or mucous colic, the patient suffers from chronic constipation, but is now and then seized with attacks of violent pain, chiefly in the left side, due to a spasm of the colon, which is followed by the passage of large quantities of mucus or mucinoid material. The attack lasts a few days, during which time there may be frequent stools, attended by the passage of a little blood, which oozes from the mucous surface. In the intervals the health of the patient may be pretty good, except for the constipation. (3) *Membranous colitis* may be divided into two groups. In the first may be placed all those which are associated with some other

grave condition, the colon being inflamed and covered with a pellicle or membrane consisting partly of mucous and partly of inflammatory exudation. Such a condition occurs occasionally in the course of specific fevers, pyæmia, pneumonia, Bright's disease, and from the effect of powerful irritant poisons. The other group, which is of more interest to us, includes all those cases connected with a considerable amount of dyspepsia and the passage of "skins" or membranes.

The cause of membranous colitis has not been definitely settled. It is considered by some authorities that its origin is due to inflammatory changes. This is supported by the fact that over 40 per cent. of the cases are associated with diseases of the pelvic organs, such as dysmenorrhœa, membranous dysmenorrhœa, endometritis, pelvic cellulitis, etc., which suggest a local origin for the disease. The almost constant association of constipation with the disease suggests that its origin lies with the intestinal atony. It is urged in support of this theory that all the successful modes of treatment depend upon keeping the colon empty. Against this theory is the fact that constipation is an exceedingly common complaint, whereas membranous colitis is comparatively rare. The frequent association of the disease with neurasthenia, hysteria, or hypochondriasis, has suggested that membranous and mucous colitis are primarily due to the nervous disorder. Nothnagel considers the disease primarily a nervous disorder, with an excessive secretion of mucus from the colon as a symptom. Ewald says colica mucosa is a myxoneurosis. The neurotic origin of the disease is founded on the following facts: (1) The disease affects persons of a neurotic disposition; (2) an attack of mucous colic can be brought on by severe emotion; (3) inflammatory diseases of the colon do not cause such a profuse discharge of mucus as occurs in this disease; (4) the post-mortem examination of persons known to have suffered from the disease is against the inflammatory origin. It is possible that the symptoms of the disease occur as a vicious circle. Beginning with enfeebled nervous system, there first arises the atony of the muscular coat of the bowels, which leads to constipation. The frequent delay in the passage of fæces permits the absorption of products of protein decomposition which poison the nervous system and cause neurasthenia, and the neurosis gives rise to the perverted secretion of mucus. The intestinal bacteria are of two kinds: those which act upon carbohydrates and produce lactic, acetic, butyric, and succinic acids; and those which act upon and decompose proteins. The former are confined more or less to the small intestines; the latter to the colon, and chiefly to the lower two-thirds. But there is an intermediate region, consisting of the cæcum and ascending colon, where both kinds of bacteria flourish even in health. In the normal condition the protein-decomposing bacteria do not extend above the ileo-cæcal valve; but in pathological conditions they do extend above this region, and become exceedingly active, whence arises the decomposition of proteins

and absorption of the toxins arising therefrom. Mucus is the natural lubricant of the colon, and is necessary to facilitate the expulsion of fæces. A diminished secretion is considered to contribute to the causation of constipation; but an excessive secretion is abnormal and pathological, and especially where the character of the secretion becomes altered so as to form " skins," and the large flakes of laminated material which characterize membranous colitis.

The disease, however, is rarely fatal; but it drags through a prolonged period, and the patient may die through some intercurrent affection. Providing the latter is avoided, the patient may get well; the disease may be cured. But very many patients suffer for years before proper treatment is begun, and such delay diminishes the prospects of complete recovery. Moreover, about half the persons affected get well. Men do better than women. Most of the patients require a long and patient treatment. If patients neglect their treatment, the disease goes from bad to worse. They become thinner, paler, more anæmic, and feebler; they alternately lie in bed, too ill to move, or occupy themselves in going from one health-resort to another, and their existence becomes miserable. There are, in fact, few chronic diseases which have a wider ramification and produce more serious ill-health than membranous colitis.

With regard to Treatment.—The diet is of the utmost importance, but the form depends upon our view of the ætiology. If, from our consideration of the case, we have concluded that the enteric catarrh, mucous or membranous colitis, had its origin in congestive or inflammatory processes, it is clear that the food must not consist of those articles which have been recommended for constipation. On the other hand, we must prescribe substances which will leave no irritating residue. It is possible that a course of Fletcherism (*q.v.*) might be beneficial. At any rate, nothing should be swallowed that is not reduced by the teeth to a consistency fine enough to pass through a sieve. Indeed, it is sometimes necessary to interdict the consumption of food which has not been passed through a sieve. It is necessary, above all things, that the patient should avoid all " skins and bones, strings and stones." Thus, the skin and fibrous portions should be removed from meat, fowl, fish; the scales should be carefully removed from sardines (if they are eaten); all bones and spicula of bones must be avoided. The skins of potato, tomato, grapes and other fruit must be removed; also the white or pulpy portion of oranges, the strings taken out of various fruits, the skins removed from the interior of apples. The seeds must be removed from grapes, currants, strawberries, gooseberries, figs, and all other fruit. The patient must avoid fibrous vegetables, such as cabbage, savoy, Brussels sprouts, turnips, swedes (*Ruta baga*), parsnips, and carrots, unless they have been reduced to a purée. Also brown bread of all kinds, rye bread, oatmeal, new bread, crust of bread, dry toast, hot buttered toast, muffins, crum-

pets, pastry, boiled puddings, nuts of every kind, dried currants, raisins, candied fruits, peas and beans, salted meat or fish, hard-boiled eggs, cheese, sardines, pilchards, whitebait.

The food may consist of the following articles, and should be taken in abundance, so as to renovate the organism and increase the muscular energy. All kinds of fresh meat, fowl, and fish may be allowed, with the foregoing proviso—*i.e.*, after removing skin, gristle, and bone, and resorting to extremely careful mastication. The gravy from any kind of meat may be taken, unless diarrhœa is a marked feature of the case. Ox or calf's tongue, potted meat, scraped meat, chicken soufflé, and similar articles are very useful foods. Raw and soft-boiled eggs are equally suitable. Sole, plaice, whiting, turbot, and brill are suitable fishes, care being taken to avoid skins and bones. As the treatment progresses, beef or mutton which has not been scraped or minced may be taken if every particle of skin and fibrous tissue is removed.

Plain white bread (avoiding crust) is always permissible, but it should be stale and good. Bread-and-butter, plain biscuits or crackers, rusks, Madeira cake (without fruit), and sponge cake may also be taken.

The vegetables allowable are vegetable marrow, spinach, well-mashed potato or potato purée, and any other vegetable which has been rubbed through a fine sieve. The patient may have a considerable amount of fruit if care is taken to avoid indigestible residues. Cooked apples and plums or peaches are easily prepared. Strawberries, raspberries, currants, and gooseberries can be reduced to a pulp and passed through a sieve, to be eaten with cream and sugar or with blanc-mange or milk pudding. The soft part of oranges can be eaten; grapes can be freed from skins and stones; bananas can also be freed from skin and the string in the centre.

Puddings consisting of rice, sago, tapioca, rendered quite soft, are useful. Custard, junket, blanc-mange, and all kinds of jelly leave little residue. Jelly made of agar-agar is permissible. Farinaceous foods, such as Benger's, Savory and Moore's, and many others, may be consumed. The casein preparations may all be used. Honey, treacle, fruit-syrups, black currant jelly, apple jelly, quince jelly, can all be allowed.

Soups are permissible if they are carefully prepared. Any kind of meat or fowl can be used in their manufacture. All kinds of vegetables or pot-herbs can be used in the preparation of such soups, but they should then be removed. The soup, however, may be thickened if it is desired, and vermicelli or macaroni may be cooked and eaten with it; or the soup may be made of stock flavoured with essence of celery, tomato sauce, or mushroom ketchup.

If diarrhœa is a marked feature of the case, or occurs in the course of the disease, it is necessary to stop all soups, beef-tea, meat essences, meat jelly, vegetables, and fruit. Milk should then

be the staple food, but even this does not always agree with the patient. When milk does not agree, the patient may have a farinaceous gruel made of Benger's or Savory and Moore's food, baked wheat-flour, biscuit-powder, fine oatmeal, arrowroot, tapioca, or sago cooked to a jelly, some form of milk-powder (Sanatogen or Plasmon) being added to supply protein. After a day or two of this diet the white of an egg may be given two or three times a day in arrowroot gruel or lemon-water, and followed by Brand's essence, Valentine's meat juice, or Mosquera's beef jelly. As the diarrhœa subsides, an experiment can be made with a little scraped meat or chicken pañada, and if these are borne well, we may then pass along to boiled tongue, boiled tripe, a portion of sole or plaice, and thenceforward get on the foregoing diet list.

If, on the other hand, we have concluded that the predominating feature in the ætiology is a neurotic condition, and if we have ascertained that the commonly associated pelvic and other inflammatory troubles are absent, we should adopt another course. The best dietary to adopt in such cases is the **cellulose diet** recommended by Von Noorden. This has been given in the chapter on Special Diets. Von Noorden prescribes a diet consisting of ½ pound of Graham bread, with all kinds of legumes, such as dried peas and beans, vegetables containing much fibre, and an abundance of fruits having thick skins and a large quantity of seeds (grapes, currants, strawberries, gooseberries, and blackberries), plenty of fat, such as butter, bacon, fat ham, and fat meat. He claims that with this diet 50 per cent. of the cases are permanently cured, and another 28 per cent. are greatly improved. The food should be a lacto-vegetarian diet having the following basis: Milk 2 pints, eggs two or three, brown bread 8 ounces, butter 2 ounces, fat meat, fat ham or bacon. The following combination may be suggested:

Breakfast.—Hot water, ½ pint, while dressing. Coffee or China tea, cream; brown bread-and-butter; oatmeal porridge, with cream and demerara sugar; light fish; fat ham or bacon; or eggs, scrambled or poached; jam, marmalade, honey, treacle; raw fruit.

Lunch.—Glass of milk and oatmeal biscuits or parkin.

Midday.—Omelette, buttered or scrambled eggs; or fat meat. Bread-and-butter. Artichokes, tomatoes, green salads, cabbage, savoy, cauliflower, spinach, turnips, swedes. Raw or cooked fruit, the following combinations being useful: Apples, walnuts and figs; pears, hazel-nuts, and dates; prunes, bananas, and brazil nuts; grapes, brazil nuts, and figs; strawberries, walnuts, and dates; blackberries, peanuts, and pears; bananas, figs, and hazel nuts. Cooked fruit may be eaten with cream.

Tea.—China tea, cream; currant cake.

Dinner.—Similar to midday meal. Boiled peas and beans may be used in alteration with fruit and nuts.

The food must be abundant, or in sufficient amount to yield not less than 70 grammes of protein and 2,000 calories. The unfortunate part about such patients is that their appetite is small, they soon feel full, and there is a danger that such persons may delude themselves that they are doing well if they take a glassful

or two of milk and little raw fruit. If this treatment is prescribed, it must be carried out completely, for half measures are worse than useless, and simply lead to an aggravation of the neurotic condition and its attendant state of subnutrition. The disease can only be cured by raising the tone of the body, improving nutrition, and correcting the constipation. Obviously, a cellulose diet is unsuitable in cases of enteric catarrh attended by diarrhœa; but in a large number of non-ulcerative cases, such as mucous and membranous colitis, the lacto-vegetarian or milk and fruit diet is very successful.

All cases present difficulties, and therefore it is impossible to prescribe the cellulose diet to everyone. For instance, there may be a chronic gastric catarrh or a gastric neurosis, which prevents the use of such a diet. In others, a coarse cellulose diet, containing peas, beans, and fibrous vegetables, may precipitate the attacks of mucous colic. In such cases a diet consisting of fruit and milk and eggs may be beneficial—*e.g.*, 2 or 3 pints of milk, two or three eggs, with cooked apples, pears, plums, prunes, bananas, grapes freed from seeds, dates, and nuts ground in a mill. Even this may be too irritating, and the case is one which can only be treated by a diet as free as possible from residue or by a course of Fletcherism.

In very severe cases it may be necessary to prescribe absolute rest in bed, with warm applications to the abdomen and occasional injections of morphine. The use of narcotics, however, should be avoided as much as possible, and they should never be given into the hands of the patient, because they increase the constipation, and sufferers from mucous or membranous colitis are very prone to use them freely, and a condition of morphinomania may be induced.

The colon must be kept empty, for very little improvement can be made while constipation remains. Castor oil (ʒss. to ℥i. every morning) is, perhaps, the most useful aperient; but calomel followed by an aperient water is also useful in many cases. Whatever aperient is found to agree must be taken for months together. The use of agar-agar or regulin may also be tried. Pure petroleum is useful in many cases (see Constipation). If these measures fail, resort must be had to intestinal lavage, which is best carried out at Plombières with the water of the place. Lavage can be carried out at home with a pint or two of plain water or a solution of common salt and bicarbonate of soda at 104° F.; but lavage of the bowels is seldom so successful when carried out in this country as when done at Plombières, whence it must be concluded that the special water of that place has a curative value.

Hot baths, followed by massage, electricity, and abdominal exercises, are all useful to improve the circulation; and a wet pack or compress worn over the abdomen, and bound on by a flannel bandage every night, is beneficial. Priessnitz recommends a similar compress.

Some form of occupation must be found for the patient. Such people are always worse when they have nothing to do. An out-of-door life is beneficial, but the amount and kind of exercise must depend upon their condition and the nature of the case. Tennis, badminton, golf, walking, and riding are useful for increasing muscular tone, encouraging appetite, improving the circulation, and stimulating peristalsis; but obviously these exercises are too severe for all cases. If diarrhœa prevails, quietness should be the rule, fresh air being taken by riding in a carriage, sitting in a garden, or a sea voyage. Above all things, the patient must not be allowed to be solitary. Changes of place and scenery are useful by taking the patient's attention from themselves, and they are still more useful if the air is bracing, as upon the sea, or the mountainous districts of Wales, Norway, or Switzerland.

When all other means have failed, and the suffering is so great as to render life a burden, the colon may be opened on the right side to allow the fæces to come through an artificial anus for a few months, and give rest to the diseased bowels. The opening may then be closed up. This treatment was first adopted by Hale White and Golding Bird in 1895. It has since been followed by many operators, and is often successful in curing membranous colitis. The objections to the operation are—The fæces are often so fluid that it is impossible to keep the patient clean; the irritation of the fæces makes the skin sore; when the disease has lasted many years, the neurotic condition often remains after the membranous colitis is cured. When these things are explained to the patient beforehand, she frequently prefers the evils she knows to those which are unknown. Some surgeons perform appendicostomy—that is, they cut off the end of the appendix, and sew it to the edges of the skin. The object of this operation is to provide an opening through which the colon can be washed daily with a boracic or other lotion, thus keeping the colon clean and empty. Hale White considers that with a right-sided colotomy there is no need to syringe through the artificial anus to the rectum. Other surgeons, including Arbuthnot Lane, prefer to join the ileum to the rectum, thereby short-circuiting the bowel, or even to remove the entire colon. One of the main objections to this operation is that the rectum itself may be badly diseased or the only part which is diseased, and it may be difficult to implant the ileum below the diseased part, and therefore colotomy or appendicostomy is preferable. Hertz considers that removal of the colon is unnecessary in any condition except **Hirschsprung's disease.** The latter is an idiopathic dilatation of the colon, which begins in early life. It is an uncommon affection. The dilatation may extend from the cæcum to the anus, and is probably one of the forms of "phantom tumour." Out of twenty-four cases collected by Crozier Griffith, only three reached adult life; but it is possible that slight cases may occur, and form the elderly group which has been recorded. The dilatation of the colon may become extreme. The

abdomen, however, is usually distended, but the greatest distension is usually in the iliac fossa. The distension impedes the breathing, and causes lividity by hampering the action of the heart and organs of respiration. The hepatic dulness is diminished, and the liver cannot be felt. Peristaltic movements are visible, and the change in the shape of the abdomen can be seen slowly taking place. The condition renders life burdensome. Death often arises from colitis or ulcers, which may become perforated. The removal of the colon is the only treatment likely to be beneficial.

CHAPTER XI

DISEASES OF THE LIVER

The liver is the largest gland in the body, and its functions are multifarious. It is easily understood that such an organ may be upset in many ways, and the nutrition and metabolic processes of the body unbalanced, because so important an organ is thrown out of gear. It is not easy to test the hepatic efficiency by physical methods; and perhaps the best means of doing so is to observe the relation which exists between the amount of bile in the fæces and urine. The occurrence of little bile in the urine coincident with a marked deficiency of bile in the fæces would indicate a high degree of hepatic insufficiency. A normal amount of bile in fæces, coupled with a slight increase of bile in the urine, would indicate a slight insufficiency of the liver. Absence of bile from the fæces and excess of bile in the urine would indicate insufficiency of bile due to catarrhal or other obstruction of the bile channels; and the presence of bile in the fæces, coupled with excess of bile in the urine, would indicate some disease of the liver, but not biliary insufficiency.

Torpor of the Liver is the most common liver complaint. The organ is slow in performing its normal functions, and tends to become choked with bile, glycogen, and urea. It has a marked tendency to run into chronic congestion of the liver. There is a normal increase in the amount of blood in the liver after each meal. This is physiological. But when persons eat and drink immoderately, the physiological fluxion becomes excessive, continues longer, and, being often repeated, tends to cause a permanent dilatation of the bloodvessels. Moreover, the fluxion may be aggravated by "a chill," when an acute congestion or pathological hyperæmia occurs in a small or large area of the liver; or the fluxion may be aggravated by an irritation of the parenchyma of the liver by alcohol and spices. The parenchyma is affected so much by alcohol in the blood of the portal vein that it offers but slight resistance to the dilating vessels. *Ubi irritatio ibi fluxus:* This is apparent when mustard, horseradish, pepper, cayenne, and other irritants are applied to the skin, and probably holds good in the liver. But the chronic congestion of the liver which occurs in heart disease, chronic bronchitis, pleurisy, and other obstructive diseases, arises from passive hyperæmia, due to backward pressure, whereby the vessels of the liver are mechanically distended. The influence of excessive eating and the use of spices and alcohol in causing chronic

hyperæmia of the liver has been referred to. There are other effects. In all chronically inflamed organs the amount of fibrous tissue becomes greatly increased. The liver is no exception to the rule, and the formation of new fibrous tissue is a very prominent factor in cirrhosis. We ought to consider the nature of the irritant which induces this fibrosis. As the disease is spread throughout the liver, the irritant must be something in the blood circulating through it. The name "gin-drinker's liver" involves the view that alcohol is the common irritant; but it is known that ether, chloroform, phosphorus, and other irritants will produce the same effect. Alcohol in the form of spirits is the usual cause; wine and beer do not often cause it. But other causes are indicated from the fact that the disease occurs in animals and children who have never tasted alcohol. A case of typical cirrhosis was observed in a butcher's cat, which suggests that the disease was due to excessive eating. It is probable that alcohol is not the sole cause of cirrhosis, but that it is due to toxins which cause proliferation of the connective-tissue cells, and these may include toxins from meat, butyric acid, etc. In the early stage of cirrhosis the new tissue is abundantly cellular, like granulation tissue. Horsley expresses the opinion that "if the irritant [alcohol] is removed after being used a short time only, the liver will go back to what it was before the irritation occurred; the new cells will disappear. But if the irritant be applied again and again, small quantities of alcohol constantly filtering through the liver, a time comes when these cells settle down into permanent fibrous-tissue cells, or 'scar tissue.' A peculiarity of scar tissue is that it can never be removed." The areas of hepatic tissue encroached on by the new formation undergo fatty degeneration by being deprived of nutriment. This fatty change is different from fatty infiltration. The latter occurs in conditions like obesity and other forms of defective metabolism, such as arise from beer-drinking, sedentary occupations, luxurious habits, living and working in hot and badly ventilated rooms, and the absence of fresh air and muscular exercise.

The treatment of **torpid liver** is by medicinal, hygienic, and dietetic measures. The liver may be influenced in many ways. Abstinence from food for a short time will help to relieve the torpidity by making demands on the liver to supply the organism with glycogen. We can prevent any increase in the accumulation of nitrogenous waste products by withholding protein foods. By sweeping the intestinal canal of its entire contents, we can provoke the liver to activity in supplying glycogen for the tissues and bile for digestion. The liver cells can be stimulated to biliary activity by various drugs, and the *vis à tergo* will cleanse the hepatic ducts and bile channels of the materials accumulated during the period of torpidity. The large watery stools induced by free purgation relieves the pressure in the portal veins, increases the diuresis and excretion of urea and other products of protein metabolism, and relieves the system in general.

The dietary for torpid liver, or "liver complaint" is much the same as for indigestion. If there is a deficiency in the secretion of bile, it is obviously better to avoid fatty foods, especially foods cooked in fat, and goose, duck, pork, fat bacon, or other articles containing very much fat. The aromatic spices and condiments, such as mustard, pepper, horseradish, ginger, cayenne, cloves, mace, nutmeg, etc., should all be avoided, because of their effect on the portal circulation. An excess of alcohol must be avoided, because it is directly irritating to the hepatic structures. The total dietary should be temporarily reduced to about 1,800 or 2,000 calories, including at most 80 grammes of protein, 40 grammes of fat, and 280 to 300 grammes of carbohydrate. It should be selected from the following articles:

Soups.—Vegetable soup or light clear broth, containing little extractive matters, and made chiefly of leeks, onions, celery, turnips, carrots, mint or thyme, and bones.

Fish.—Sole, plaice, whiting or haddock; boiled cod, bass, perch, pike, brill, skate, or flounder; raw oysters.

Meat.—Tender mutton, lamb, chicken, pheasant, or rabbit. These foods should be boiled, as that method of cooking removes a considerable proportion of the extractives.

Carbohydrates.—White or brown bread, dry toast, rusks, or rolls; plain milk puddings, custard (no jelly), blanc-mange; potatoes, cabbage, cauliflower, spinach, Brussels sprouts; endive, lettuce, tomatoes; and fruit may form part of the dietary.

Hygienic measures must be adopted. In particular, it is necessary to take plenty of muscular exercise; to live in well-ventilated rooms, not overheated; to drink plenty of water and other simple beverages. Massage of the liver is sometimes very beneficial.

The treatment of a "**bilious attack**" is very simple. The name is unsatisfactory, and conveys little information. A bilious attack is usually due to gastro-duodenal catarrh, associated with acute hyperæmia of the liver. It frequently follows dietetic excesses, but may be purely the result of chill, and is often of bacterial origin. The headache, vomiting, and general malaise necessitate *starvation* for twenty-four hours, and the use of calomel and salines to clear the alimentary canal of bile and food residues. On the following two days the food should consist of milk, oatmeal, hominy, light fish or chicken, milk puddings, junket or custard, toast or rusks. The subsequent treatment should be that of "liver complaint."

The treatment of a **liver chill** consists of rest in bed and the use of means to relieve pain and febrile symptoms. The application of cotton-wool, poultices, or a counter-irritant, over the hepatic area will be found soothing. A few leeches to the anus afford relief by withdrawing blood from the portal veins. The same effect follows the action of a strong saline aperient, which relieves the portal system by the removal of water. The food must be unstimulating and unirritating. Milk is the food least irritating to the alimentary canal, and it contains practically no

extractives which could irritate the liver. An abundance of liquid would be useful by making the bile more fluid, and the presence of sodium salts would likewise encourage a flow of thin bile. It is therefore advisable to dilute the milk with Vichy, Vals, Ems, or Apollinaris water, or, in their absence, by ordinary soda-water. A little fish of a light character, preferably boiled to remove extractives, may be allowed, and it may be accompanied by cabbage, cauliflower, spinach, vegetable marrow, or French beans. Bread-and-butter, milk puddings, and weak tea are allowable in moderation; but the food must be small in quantity until the congestion has passed away. It should be reduced to the physiological minimum—1,500 or 1,600 calories for at least two days—and the diet should include not less than 2 pints of milk. If the patient wants more food, let him have a jelly made of agar-agar (Chinese gelatin), prepared with a fruit flavouring, or eaten with a little cooked fruit. A few strawberries, raspberries, gooseberries, or a roasted apple or two are also permissible ; but fruits which contain much starch, such as bananas, and potatoes, should be avoided. Ordinary gelatin and jelly made therefrom—*e.g.*, calf's-foot jelly and jelly tablets—are not permissible. Gelatin is a nitrogenous body, but the nitrogen does not spare the tissues very much; it is of no more value in most cases of sickness than carbohydrates; indeed, the amino-acids are split off during assimilation and immediately carried to the liver for transformation into urea. Agar-agar is scarcely digested at all, and merely satisfies the stomach by giving it something to act upon.

In **hyperæmia** due to fluxion of blood to the liver, as a consequence of immoderate eating or drinking, the excessive use of condiments, spices, or alcohol, the dietary and habits of the patient must be rearranged. Instead of luxurious living, the diet must be plain and spare. It is particularly desirable that alcohol should be reduced in amount or forbidden altogether; mustard, pepper, capsicum, horseradish, and other spices which cause an afflux of blood to the liver, must be forbidden. The dietary which has been recommended to be eaten and the articles to be avoided in indigestion and chronic gastric catarrh are applicable in the treatment of this complaint. The amount of protein should be reduced—for some time, at any rate—to the physiological requirement; and in no case should it exceed 70 or 80 grammes a day until the liver has attained something approaching to the normal condition. "Rich" and fatty foods should be avoided, because they tend to aggravate the general catarrhal condition of the alimentary organs. But as 50 per cent. of the fat reaches the circulation through the lymphatics and not through the liver, there is no reason for reducing the amount of fat below 100 grammes daily, and it should be taken in the form of butter, cream, and fat meat. The carbohydrates should be given in the form of bread, milk pudding, and fruit; it should be reduced to 240 or 280 grammes. With 70 or 80 grammes of protein and 100 grammes of fat, the diet will yield a total of 2,000 to 2,200 calories a

day. The consumption of alcohol has to be considered most carefully. It ought to be done without altogether, but a good deal depends on the condition of the patient. Malt liquors and spirits are particularly forbidden. But wine, such as moselle, hock, sillery, Burgundy, or red Hungarian wine, is permissible with the meals. It should be understood that the amount is to be strictly limited—two wineglassfuls at the most. Hygienic measures are of importance. Fresh air and exercise are essential. The patient who has been accustomed to ride in a carriage should be recommended to walk. Golf is an extremely useful means of getting fresh air and exercise. Tennis, badminton, bowls, quoits, and walking, are also useful means of exercise. The importance of the muscles for destroying uric acid and other waste products has been established. The ventilation of the rooms occupied by the individual when at home or in the office should receive due attention. Other remedial measures should not be neglected. Brisk purgation clears the alimentary canal of bile and imperfectly digested food, relieves the congestion of the portal vessels, stimulates absorption and bile formation. The activity of the liver is thereby stimulated, and the accumulated products of metabolism are reduced to urea. Nothing surpasses the alkaline-sulphate or saline purgative waters for this purpose. The sulphates encourage the biliary secretion and relieve the lateral pressure in the portal system by depleting the intestinal veins. The sodium salts enter the blood, and being excreted by the kidneys, promote urea excretion, and thereby relieve the liver. The alkaline carbonates neutralize excess of uric acid, and remove it from the body in the urine. The waters most suitable for these purposes are those of Harrogate and Leamington, in England; Marienbad, Homburg, Carlsbad, and Kissingen, on the continent of Europe; and those of Saratoga-Vichy and Hot Springs of Arkansas, in the United States. All these waters may be used for a long time without injury.

We have still to consider that large group of cases of hyperæmia of the liver due to passive congestion, arising from diseases of the thoracic viscera. In a considerable number of cardiac cases the cause of the hyperæmia is a combination of those which have been detailed under Fluxion and Congestion. Thus, cardiac myasthenia, fatty heart, and the symptoms arising from valvular diseases, may all be aggravated by alcohol, condiments, spices, overeating, and overdrinking. The patients are usually inactive or slow in their movements, and many of them are unable to be otherwise. They suffer from dyspnœa, and sometimes a slight, or even a well-marked, cyanosis. They may have œdema of their feet and ankles, possibly some ascites, alternate diarrhœa and constipation, or hæmorrhoids. Their appetite is usually poor; the symptoms of gastro-intestinal catarrh are evident. Such patients may be fleshy, but their flesh is flabby, and probably contains much water. It is not what is considered healthy fat. Their condition as a rule is more serious than in the former group of cases, and they often have to take to

their bed for a few weeks owing to the state of their heart, bronchitis and emphysema, an attack of subacute gastritis, or acute gastro-enteric catarrh.

In consequence of their debilitated condition, their inactivity, poor appetite, and enfeebled nutrition, the treatment already outlined has to be modified. It is frequently necessary to put them upon a milk diet, with Benger's, Savory and Moore's, or other foods, which require no mastication, and are consumed in a fluid or semifluid condition, and are easily digested. It may be necessary to put them on absolute milk diet or skim milk for a week or two. But in the majority of cases any food made with milk is good for them—*e.g.*, bread and milk, custard, junket, milk jelly, isinglass and milk, oatmeal and milk, and milk puddings. Eggs—poached, lightly boiled, or raw—are useful if they do not cause diarrhœa; but scrambled eggs or " buttered eggs " and other greasy foods are forbidden. The amount of protein should be not less than 80 grammes daily, if the patient can be persuaded to take it, and the whole dietary should yield not less than 2,000 calories. These weakly patients require to be " built up." Moreover, the proteins should be unassociated with extractives and purin bodies as far as possible. For this reason milk and eggs are the best sources. When the digestion is improved, and the appetite increased, some of the milk can be replaced by other protein foods of a light character, such as tripe, boiled cod, sole, plaice, whiting, fresh haddock, and, later on, mutton (boiled with flavouring vegetables and herbs, or with caper sauce), and boiled fowl or rabbit. A moderate amount of butter or fat meat will do no harm; but foods usually called " rich," or fried in fat, must not be given. Vegetable soup is also permissible, but not meat soup. The carbohydrates may consist of milk, sugar in tea or cocoa, bread, milk puddings, and a little fruit, such as grapes, oranges, strawberries, raspberries, bananas, and pineapple. Ordinary tea and coffee should be excluded from the dietary, but the patient may have a little China tea, or coffee *free* from caffein, or some form of imitation coffee (fig coffee, cereal coffee, dandelion coffee, etc.). Tea and cocoa should be made with milk. It is better to exclude alcohol, unless some special symptoms necessitate its use. In such a case a glass of really good sherry, or a little old and genuine brandy, well diluted, may be permitted once or twice a day. As a rule the amount allowed must be small, and strictly limited by the medical attendant.

When the patient is sufficiently recovered to return to ordinary diet, the greatest possible care must be used as regards the articles permitted. All those articles which foster hepatic hyperæmia by causing an afflux of blood to that organ or by irritating the parenchyma, must be avoided. In particular, alcohol, spices, condiments, sauces, pickles, and all foods cooked in fat must be excluded. To these should be added strong soup or broth, all kinds of extract of meat, liver, kidneys, spleen, brain, sweetbread, high

game, pork, veal, sausage, duck, goose, hashed meat, dried and salted meat, heavy kinds of fish—*e.g.*, mackerel, herring, salmon, salmon-trout, eels, lamprey, butterfish, catfish, ciscoe, halibut, mullet, pompano, shad, trout, and whitefish—cheese, heavy vegetables—*e.g.*, carrots, turnips, parsnips, swedes, cabbage, yams, dried peas and beans—and fruit containing many seeds, such as gooseberries, currants, cranberries, figs, etc.

The liver may be relieved to some extent by the use of Carlsbad, Marienbad, Friedrichshall, and similar waters. If the patient can travel, he may be sent to Harrogate, Leamington, or one of the Continental spas. It is obvious that such persons will not be able to take active exercise, but they must go into the fresh air whenever they can, should walk when they are able to do so, and when they cannot walk, should ride in an open carriage.

When considering the diet suitable for hepatic disorders, Emil Schwarz[1] took into consideration the influence of the liver itself. He says the influences exerted by the liver on albuminous, starchy, and fatty foods, and on the final products of nitrogenous metabolism, are not independent processes, but are the final stage of a complicated process, taking place in the cells of the liver. Therefore, when the parenchyma is affected, all these processes suffer simultaneously, if not equally. But it is only in the most acute hepatic diseases (acute yellow atrophy of the liver and phosphorus-poisoning) that intoxication occurs from the products arising at the end of digestion or metabolism. In chronic diseases of the liver it is only in the final stages that metabolism suffers. Therefore Schwarz sees in the liver itself no reason for diminishing either the nitrogenous or amylaceous foods, or even the fatty foods, unless there is jaundice. But the digestive tract is involved in a catarrhal process arising primarily from the ingesta which have caused the hepatic disease—*e.g.*, alcohol—and secondly from portal congestion, which causes a delay in absorption. The surface available for absorption is reduced, often as much as one-half, by the catarrh and atrophy of the mucous membrane arising from periphlebitis of the portal system and chronic peritonitis. The stagnation of the ingesta leads to an increasing acid intoxication. While he considers that there is no necessity for reducing the intake of protein any more than the fat or carbohydrate, he found everything indicates that the food should be capable of rapid conversion into absorbable material, that it should be small in quantity, and leave very little residue after digestion. He therefore recommended that in all serious cases an exclusive milk diet should be tried. Even when the degenerative processes are of a serious nature, they are not necessarily progressive, and therefore, by excluding further injury, a permanent improvement in the patient's condition may be made. But the continued abstinence from alcohol is necessary in every case for the encouragement of improvement. The adverse influence of caffein on the glycogenic function of the

[1] *Centralbl. f. d. Ges.-Therapie*, August, 1899.

liver also suggests the absolute exclusion of coffee, and tea should only be taken in a very weak form.

It is seldom that **fatty liver** is a distinct and separate object of medical treatment. When the enlargement is due to fatty deposit in the liver of persons who are perfectly healthy, our efforts at treatment must be guided by our knowledge of the habits and tendencies of the individual. When the fatty liver depends on actual disease, it is essentially by treating that disease that we may hope to remove the hepatic accumulation.

When it occurs in persons who eat or drink excessively, the causal indication demands a thorough change in the mode of life. The treatment is practically that of obesity (*q.v*). General advice is useless, because it is seldom followed. If the treatment is to be successful, the amount and kind of food, drink, and exercise must be carefully planned and written down for the guidance of the patient. The dietary should be cut down to 1,800 or 2,000 calories. There is no need to cut out the fats from the food, so long as there is an absence of jaundice; but they should be reduced to 30 or 40 grammes a day at the most, and this can be done by forbidding fatty substances—*e.g.*, fat meat and articles cooked in fat, and very much butter. Neither is there any necessity to forbid carbohydrates entirely, but they should be reduced to 100 or 150 grammes a day, forbidding potatoes, sugar, cakes, jam, marmalade, milk puddings, and all other sweet articles, and reducing the bread to 3 or 4 ounces daily. The patient may have an abundance of fresh vegetables and fruit, which may be selected from the following: Cabbage, Brussels sprouts, savoy, kale, cauliflower, turnips, artichokes, *Stachys tuberifera* green salads, lettuce, watercress, endive, chicory, dandelion, sorrel; apples, pears, oranges, grapes, tomatoes, and bananas (not too freely). Carrots and potatoes are not good for people with liver disease, the latter because they are too starchy, the former too sweet. It is not known whether **carrotin** has any influence on the hepatic functions, but as it is allied to cholesterin, it is better that carrots should not be consumed, owing to the tendency in hepatic diseases to the formation of gall-stones. The patient should not have rich or fatty soups, nor those thickened with flour, pea-flour, lentils, or beans. Vegetable soups are as a rule good. Boiled meat or fowl are better than any other form of meat, because boiling extracts a portion of the meat bases and purins. Tea and coffee should only be taken in moderation, owing to their containing xanthin bases. The patient should be encouraged to rise early and collect his own salads before breakfast. The following dietary is useful:

Breakfast.—Eggs, one or two; lean ham, 1½ to 2 ounces; stale bread without butter; watercress, lettuce, dandelion leaves, endive, or tomatoes.

Dinner.—Vegetable soup, made with milk; boiled meat, fish, or fowl; cabbage, savoy, cauliflower, etc.; 1 ounce of bread; one or two *new* potatoes, artichokes; a small piece of cheese; tomatoes, and lettuce. Raw fruit, cooked fruit, and custard or junket.

Tea.—A cupful of China tea; ½ ounce of bread-and-butter if desired; strawberries, raspberries, apple, pear, apricot.

Supper.—Half pint of milk, ½ ounce of oatmeal (rolled oats, Quaker oats, Provost oats, coarse oatmeal) made into gruel; *or* vegetable soup, ½ pint; 1 ounce of bread-and-butter; fruit, raw or cooked.

The indications for treatment arising from the disease are also important. They are derived from the following considerations: (1) There is less fat in the hepatic than in the portal vein; (2) the secretory activity of the liver cells diminishes as the fat in them rises. Therefore drugs should be given which are known to have a cholagogue effect. The free and continued use of mineral waters containing sulphates and alkaline carbonates have a good effect by increasing the flow of bile and reducing the general accumulation of fat in the body. The superfluous fat of the body disappears, under the influence of the waters at Harrogate, Carlsbad, Marienbad, Homburg, Kissingen, etc. After a month's residence at Harrogate or one of the Continental spas, taking the water regularly and under medical direction, most patients return home much thinner than they went there. There is no doubt that the change in the mode of life, the increased amount of exercise, and moderation of the dietary, have much to do with the effects of residence at such places. But these alone are not sufficient to clear the liver of superfluous fat and rob the body of its weight. In a very large percentage of cases the waters are more or less essential. The action of these liquids is not quite clear, but the system of a Carlsbad patient has been likened to a soap factory, in which the sodium of the water and the fat of the body are the sources of the soap which forms a part of the fæces. Whatever the explanation may be, there is no doubt about the effect of such waters in fatty liver, and this course of treatment is recommended for all persons who are obese and suspected to have fatty infiltration of the liver.

But neither the spa treatment nor the dietary outlined above would be correct for a phthisical person, nor any other patient suffering from cachexia, and suspected of having fatty infiltration or degeneration of the liver. In such cases the food must be nourishing and stimulating; the proportion of fattening materials must not be reduced in amount. On the other hand, the diet must be supplemented by plenty of milk and casein preparations, eggs, easily digested meat and fish, and light forms of carbohydrate foods, such as milk puddings, custard, junkets, and farinaceous materials. The treatment should consist of superalimentation instead of diminution in the calorie value of the food. The liver may be stimulated by mild drugs to secrete more bile and assist in relieving the organ of its burden. The same method will promote the absorption of fat from the alimentary canal, and assist in counterbalancing the losses due to emaciation. The alkaline sulphates should not be given in these cases, but the organic cholagogues may be given in the place of them.

The treatment of **cirrhosis** depends partly upon the findings of men who have experimented on the metabolism of nitrogen.

Harley and Labadie-Legran found that the variations in the excretion of urea are dependent more on the general nutrition than on the condition of the tissues of the liver. This conclusion was confirmed by the observations of Favitski of St. Petersburg,[1] who found that the metabolism of nitrogen in subjects with cirrhosis of the liver approaches that of healthy persons. On a mixed diet the assimilation was 84 to 94 per cent., and therefore not quite normal, and the quantity of urea varied from 14 to 45 grammes daily—the usual quantity being from 25 to 35 grammes. The excretion of uric acid was in most cases parallel with the variation in the urea. The absolute amount of extractives in the urine was not large, and did not vary very much from that in a healthy man. It may be deduced from these observations that the quantity of nitrogenous food should not be reduced, and that is partly correct; but the nitrogenous food should be light, easily digested, not too abundant, and not too stimulating. It is exceedingly important that the gastro-intestinal catarrh be taken into consideration, and it is perhaps more on this account than because of any change in the liver that we need to study the kind and quantity of the nitrogenous food. Milk is undoubtedly one of the best sources of protein in such cases, and there are times during the course of the disease when an entirely milk diet for a week or two is essential—milk, peptonized milk, junket, milk jelly, milk soup, or milk and invalid foods. These periods are determined by the general condition of the patient and by the variations in the catarrh of the gastro-intestinal mucosa, a subacute condition necessitating a temporary milk diet. But in the ordinary course of events it is unnecessary to keep the patient on milk diet. Eggs, especially in the form of custard, are almost equally well digested, and they may be consumed lightly boiled or poached. Mutton, tender beef, chicken, pheasant, tongue, tripe, and all the lighter kinds of fish can also be taken in small quantities and at suitable intervals. The consumption of these proteins should be watched, because of the progressive emaciation. An allowance of 34 grammes of protein daily is the minimum necessary to maintain the nitrogen balance in equilibrium, providing enough energy-producing food is consumed and assimilated. But I have shown elsewhere that it is advisable that the amount of protein should not sink below 60 grammes daily for an adult; and even with this quantity the body must continue to waste unless the calorie value of the food assimilated is equivalent to the expenditure, and the expenditure is never less than 1,600 calories, unless the patient is absolutely at rest in bed. If the gastro-intestinal catarrh is really bad, it must necessarily interfere with the digestion and assimilation of all foods, and it may then be advisable to assist nature by the administration of pepsin or pancreatin. But it should not be imagined that these enzymes will improve the power of absorption, because this function is limited by reason of the catarrh and

[1] "The Qualitative and Quantitative Metabolism of Nitrogen in Cirrhosis," St. Petersburg, 1888.

portal congestion, and it is probably more defective than the digestive function. Schwarz[1] found no reason in the liver for diminishing either the nitrogenous, amylaceous, or fatty foods (unless there be jaundice and a lack of bile in the bowels). But the digestive tract is so involved in the catarrhal process, due primarily to the deleterious ingesta which cause the hepatic disease—*e.g.*, alcohol—and secondly, to the circulation being disturbed by portal congestion, that absorption is considerably delayed. In fact, Schwarz says the surface available for absorption is reduced to as much as one-half by catarrh and atrophy of the mucous membrane, owing to periphlebitis of the portal system, chronic peritonitis, stagnation of the ingesta, fermentation, and auto-intoxication. Everything indicates that the food should be in such form that it is capable of speedy conversion and absorption. The food, therefore, should be highly nutritious, small in bulk, unirritating, and leave very little residue in the alimentary canal. For these reasons Schwarz recommends, whenever the case assumes a serious aspect, a trial at all events should be made of a rigid milk diet. He says even the degenerative processes are not necessarily progressive, and by excluding further injury, a permanent benefit may be obtained.

It is said by other authorities that starch and fat should be avoided by such patients. But it is only necessary to exclude starchy foods when the digestive power is very feeble; and even then the digestion can be assisted by the use of diastase, malt extract, taka-diastase, etc. Thus, we may give dextrinized or pancreatized starch in the form of the various prepared foods sold for invalids and infants. There is no deficiency of such foods, and the variety on the market is great enough to satisfy the caprices of any invalid. But we cannot increase the absorptive power of the mucous membrane by giving predigested cereals and starches. The lack of absorption, we have said, is due to the intestinal catarrh. We cannot remove this obstruction, and therefore the assimilation of carbohydrates and proteins must fail sooner or later. So long as the patient can take carbohydrates and absorb them, they must be given to him. When he is unable to absorb them, they will undergo bacterial fermentation in the alimentary canal, and give rise to flatulent distension, which will increase his discomfort.

The supply of fat has still to be considered. There is no need to reduce the consumption of fat so long as it is saponified and absorbed. It will be saponified and absorbed while there is an adequate secretion of bile and pancreatic fluid. In ordinary atrophic cirrhosis the small biliary ducts are not necessarily implicated, bile is not usually retained, and there is little or no jaundice. In the later stages of atrophic cirrhosis, however, the mucous membrane of the bile-ducts becomes thickened, and the channels are narrowed in consequence of catarrh, and then the flow of bile is more or less hindered. In the hypertrophic form jaundice is far more common, due to the disease affecting the small bile-ducts,

[1] *Centralbl. f. d. Ges.-Therapie*, August, 1899.

which become blocked by accumulated secretions. It should, however, be observed that Mayo Robson and others consider the presence of bile in the intestinal canal is by no means essential to the absorption of fat, and that only about half of the absorbed fat goes through the liver, and the balance through the lymphatics to the systemic circulation. The usual quantity of fat may therefore be allowed the patient, only prescribing it in forms which are most easily absorbed. Milk, cream, butter, Devonshire cream, cream cheese, cod-liver oil, and fish-liver are better sources of fat than fat meat and fat fish. It is, moreover, advisable that the patient should avoid foods cooked in fat, "rich" foods, cakes, pastry, crumpets, muffins, hot buttered toast, and all articles in which lard, oil, margarine, and similar fats are used; and the main reasons for advising their rejection is because they are less readily absorbed and have an unfavourable influence on the gastro-intestinal catarrh. The dietary for chronic intestinal catarrh may advantageously be studied in this connection.

In the hypertrophic form of cirrhosis it is even more essential to exercise care in the selection of fats, because, according to very many authorities, the deficiency of bile does influence the absorption of fat. This is a point which is not settled definitely, but it is customary in all cases of jaundice, no matter what is its cause, to recommend that the supply of fat should be cut down as much as possible owing to the deficiency of bile. It is an observed fact that healthy persons having a biliary fistula, and therefore a deficiency of bile in the intestines, absorb fat nearly as well as those who have no biliary fistula. But the conditions are different in unhealthy people, and especially when gastro-intestinal catarrh prevails.

Vegetables and fruit may be allowed in both varieties of the disease to some extent; but, again, the kind and quantity must be governed by the gastro-intestinal catarrh. We may usually allow spinach, cauliflower, French or string beans, vegetable marrow, boiled lettuce and boiled beet-leaves, tomatoes, rhubarb, cooked apples, stewed pears, cooked figs, and prunes. A few raw strawberries, raspberries, currants, or an orange, may also be allowed. Potatoes and carrots are disallowed by many authorities; but purée of vegetables, consommé, milk soup, tomato soup, and mutton or chicken broth in which vegetables have been cooked, are usually permissible, providing they do not contain too much fat. The fat can be removed from broth by allowing it to become cold, when it may be taken away *en masse*.

If diarrhœa becomes a marked feature of the disease, the patient should have the dietary given under that heading. If hæmatemesis and melæna affect the patient, the food must consist of liquids for the time being, and especially of lime-water and milk, casein preparations, arrowroot or cornflour and milk, isinglass and milk. When ascites occurs, the amount of salt should be reduced, and perhaps a salt-free diet prescribed for a few weeks. A diet consisting largely of milk or milk and eggs is useful at this stage, and often

results in the removal of a large quantity of fluid from the swollen abdomen. This effect is aided by the diuretic effect of the lactose, and the limitation of chlorides. The dilution of milk is sometimes necessary, especially when patients find it hard to digest or experience a sense of fulness and weight after it. Buttermilk, whey, barley-water, oatmeal-water, Vichy, Vals, Ems, Perrier, Apollinaris, and other alkaline waters may be used for this purpose, but the consumption of diuretic waters and beverages alone seems absolutely useless against the ascites.

The beverages permissible to a cirrhotic patient must necessarily be of a non-alcoholic type. It may be asked: "What is the use of cutting off the alcohol when the patient is already doomed?" Alcohol is forbidden because it tends to increase the gastro-intestinal catarrh as well as the liver disease. By making alcohol taboo the life of the patient will probably be longer than if he continues to use it. If the disease is recognized, or even suspected, in its early stages, its progress may be arrested by strictly avoiding alcohol. Horsley[1] says: "If alcohol is removed, the condition of the liver will go back to what it was before the irritation occurred; the new cells will disappear. But if the irritant be applied again and again, these cells will settle down and develop into a permanent fibrous tissue, forming what is known as 'scar tissue,' and a peculiarity of scar tissue is that it cannot be removed." Tea and coffee should only be allowed in moderation. The patient may have a moderate allowance of liquids, up to 2 or 3 pints a day, but it should consist chiefly of the aerated alkaline waters. The alkaline carbonates are useful by decreasing the toughness of the secretion from the gastro-intestinal mucosa; they help to remove the mucus, to cleanse the surface of the membrane, and to that extent materially aid the process of absorption and assimilation. The alkaline sulphates also assist by relieving the portal congestion. It is unnecessary for the patient to go to Carlsbad, Marienbad, Tarasp, or other Continental spas if he is unable to do so; the waters can be obtained locally, or an imitation can be made by the use of the salts which they contain. Such waters will assist the stomach and bowels to some extent; but when the atrophic stage of the disease is begun, we can no longer hope to arrest its progress. All we can do is to check the increasing emaciation and growing debility of the patient. These aims are best carried out by careful attention to the dietary, by keeping the body warmly clad, by exercising it in the open air, and keeping regular and early hours.

Cancer of the Liver.

Cancer of the liver may be primary or secondary. The symptoms are always obscure in the early stage, and in some cases never become sufficiently distinctive to enable a diagnosis to be made before death. The general symptoms are those of cancer in other parts of the body, emaciation, and cachexia. If the tumour com-

1 "Alcohol and the Human Body."

presses large trunks of the portal vein, there may be a moderate degree of ascites; if it implicates the portal vein itself, the ascites will be considerable. The obstruction of the portal circulation gives rise to gastro-duodenal catarrh. Compression of the large bile-ducts causes a partial obstruction to the flow of bile, and jaundice results from it, even though there may be a sufficient flow of bile into the bowels to give colour to the fæces. If the ductus choledochus is compressed, the obstruction of bile is general, the jaundice very pronounced, and the fæces colourless. It is said that there is no jaundice in half the cases. The above symptoms are not diagnostic of cancer of the liver, and, in the absence of a tumour, would not be indicative of cancer.

The treatment of cancer of the liver is very unsatisfactory. We have to satisfy ourselves by nourishing the patient and maintaining the strength as long as we can. Nitrogenous and amylaceous foods may be given in normal quantities, their digestion and assimilation being dependent chiefly on the degree of gastro-intestinal catarrh; but if there is pronounced jaundice, it seems useless to give very much fat. Nevertheless, a milk diet is often the only useful diet. The jaundice and gastro-intestinal catarrh are our chief guides in framing a diet list; but the emaciation and increasing debility demand a nutritious food, and sufficiently abundant to prevent the loss of flesh and strength. It is advisable not to overlook the deficiency of hydrochloric acid in the gastric juice of all cancer cases, and that the administration of this acid may assist the digestion and assimilation of food.

The dietary should consist of milk, junket, eggs, meat powders (meatox, somatose, etc.), dried milk (Trumilk, Cow and Gate), casein preparations (Plasmon, Sanatogen, tilia, protene, lacumen, lacvitum), vegetable proteins (aleuronat, glidine, roborat, etc.). Ordinary meat, fish, or fowl, may be taken in proportion to the appetite and power of digestion (see Gastric and Intestinal Catarrh). The carbohydrates may consist of bread, toast, roll, milk puddings, potatoes, sugar, honey, treacle, malt extract. An excess of sugar might increase the gastro-intestinal catarrh. It may therefore be necessary to reduce the consumption of all kinds of sweets, and rely upon dextrinized carbohydrates, such as invalid foods, and to use more milk, pulped meat, pounded chicken or fish, and various meat pastes to increase the consumption of protein. If fat appears to be digested very well, cream, cream cheese, clotted cream, and butter may be taken freely; but according to most authorities fats are not absorbed very readily. The secretion of gastric juice is stimulated by soup and extract of meat, and therefore the administration of these foods may promote the digestion of proteins. By the same rule the use of potatoes may promote the digestion of carbohydrates through the influence of their asparagin, which is a stimulant of enzyme action. Spinach, cauliflower, boiled lettuce, or celery, spring cabbage; stewed fruit, and junket or custard may all be allowed if they cause no pain or discomfort.

Jaundice.

Jaundice is only a symptom. It is usually indicative of some obstruction to the passage of bile from its place of origin in the liver to the duodenum. It is not necessary for obstruction to be very great to cause jaundice. The bile-ducts contain involuntary muscular fibres which normally assist the flow of bile maintained by the *vis à tergo* originating in the secretory pressure. But these fibres are subject to atony the same as other muscular fibres, and such atony appears to be easily induced by hyperæmia and other causes affecting the mucous membrane. It is true that the liver is subjected to the pressure of the diaphragm during inspiration. But the influence of such pressure on the flow of bile must be very small in many cases, and especially in women. A slight obstruction in the biliary passages will induce a retention of the bile, and if the secretory activity of the liver cells is normal, the bile-ducts and hepatic cells become overloaded, the pressure in the lymphatic and bloodvessels is slightly reversed, whence some of the bile enters these vessels and is carried by the circulating fluids all over the body, and gives rise to jaundice and various symptoms due to the circulation of bile-salts in the blood, such as bile in the urine, bradycardia, and various evidences of toxæmia.

Compression of the bile-ducts may arise from diseases of the liver, such as tumours, carcinoma, hydatids, cirrhosis, and chronic hyperæmia. Compression may arise from the outside—*e.g.*, cancer of the head of the pancreas, enlargement of the right kidney, etc. The most common obstructive causes of jaundice are within the bile-ducts—*e.g.*, hydatids, impacted gall-stones, and catarrh of the bile-ducts. The consequences of jaundice are various. The first is a progressive and rapid emaciation of the body, and has special reference to the absorption of the food. This emaciation goes on in spite of the fact that the appetite may be, and often is, normal. The digestion and absorption of protein and carbohydrate is not much interfered with, providing there is no gastro-intestinal catarrh; but the absorption of fat is reduced to 50 or 60 per cent. of the normal proportion,[1] and the absorption of the other elements of the food is depreciated in proportion to the catarrh. Müller[2] found by observations on men who suffered from jaundice that the digestion and assimilation of protein was not quite normal, "but was very little changed." Vilizhanin[3] made observations on dogs (1) in the normal condition, (2) with biliary fistula, (3) with jaundice. He found that the passage of bile into the blood caused an intensified cleavage of protein in the organism, as a result of which there is an increased excretion of nitrogen in the urine. But some animals with biliary fistula remained well nourished, while others emaciated

1 Halliburton's "Chem. Physiol," p. 687, and Foster's "Physiol," ii. 475.
2 *Zeit. f. Klin. Med.*, xii. 57-87.
3 "The Metabolism of Nitrogen in Animals affected with Jaundice," St. Petersburg, 1883.

rapidly. The defective absorption of fat and increased cleavage of protein are a sufficient explanation of the emaciation usually observed in jaundice.

The other consequences of obstructive jaundice are believed to be a result of poisoning by bile-acids. The patient becomes languid and sleepy, has a slow pulse, an itchy skin, and other evidences of toxæmia, which are more or less marked according to the severity and duration of the jaundice. The bradycardia is one of these effects; a pulse of 40 or 50 a minute is quite common, and 20 beats per minute have been observed. It is significant that Bouchard found bile to be nine times more toxic than urine.

The dietary for catarrhal jaundice should be similar to that detailed under chronic gastric or chronic intestinal catarrh, preceded by a milk diet for two or three days; and in all forms of obstructive jaundice the food must be such as will help to raise the patient from the depressed condition which usually obtains. It should consist of various kinds of protein and carbohydrate foods in a light and easily digestible form. It is practically impossible to abolish fat from the diet, because it is inseparable from most nitrogenous and amylaceous foods. At the same time it is advisable to reduce the consumption of fat, the deficiency in the calorie value of the food being made up with extra protein and carbohydrate; and it is better to eat *cold* meat than hot. The food, therefore, should consist of tender lean beef, mutton, lamb, poultry, and game; light kinds of fish, such as sole, plaice, whiting, fresh haddock, bass, brill, cod, and turbot. Soups are permissible, especially those made of vegetables and milk, mutton broth, veal broth and bone soup, care being taken that as much fat as possible is removed. It may be argued that the presence of fat does not matter, because it will pass out with the fæces; but it is well known that an excess of fat in the food prevents the digestion and absorption of other foods; therefore, when fat cannot be digested, it is better avoided.

All kinds of vegetables are allowable, especially those which contain cellulose and tend to provoke intestinal activity—if they do not at the same time aggravate the coexisting intestinal catarrh, which requires watching. Potato, spinach, cauliflower, French beans, green peas, asparagus, boiled onions, and vegetable marrow may be allowed to all patients; but if the gastro-intestinal catarrh is very marked, cabbage, savoy, Brussels sprouts, turnips, swedes (*Ruta baga*), carrots, artichokes, sweet potatoes, and yams will be detrimental unless they are reduced to a purée by rubbing them through a sieve.

Amylaceous foods consisting of white or brown bread, biscuit (crackers), and plain cakes—*e.g.*, sponge or Madeira cake—are allowable; also light milk puddings—rice, sago, tapioca, ground rice, custard, and junket, with stewed fruit. Fresh raw fruit is good, especially the soft varieties; and practically any kind of fruit is permissible when the intestinal catarrh is not very bad.

The beverage may consist of weak tea or coffee—no cream and very little sugar; abundance of plain water, aerated alkaline waters,

especially soda or potash water, Apollinaris and Perrier. The patient may also drink ordinary solutions of bicarbonate of soda, acetate of potash, or cream of tartar in lemon-water. The diuretic action of these salts will assist in removing a quantity of bile pigment, and, when the urine is scanty, are urgently needed. Under exceptional circumstances a little good whisky or brandy, or even a little superior Burgundy or claret, may be permitted.

The foods to be **avoided** are strong soup, rich gravy, sweetbread, brain, fat meat, all kinds of fat fish—*e.g.*, salmon, trout, eel, herring, mackerel; *hot meat*, twice-cooked meat, curry, pork, veal, ham, bacon, eggs, butter, cream, cream cheese, cheese, dried fruits, and nuts; rich cakes, pastry, sweets; alcohol: beer, porter, sweet wines, and especially champagne.

The constipation which exists suggests the use of laxatives; but the causal indication must be taken into account. If the jaundice gives rise to symptoms of severe toxæmia with excitement or delirium, the application of ice or cold water to the head, and strong purgatives internally may be of use. Swallowing small pieces of ice may check the vomiting, and this treatment may be aided by foods, such as Valentine's meat juice or albumin-water (white of egg and lemon-water); and in the comatose condition the patient may be fed *per rectum* or by means of an œsophageal tube, care being taken, of course, that the tube is in the œsophagus and not in the trachea. In other cases, also, it may be necessary to confine the patient to a diet of a fluid or semifluid character—*e.g.*, milk fortified by casein preparations, somatose, glidine; powdered meat, fowl, or fish, given in soup or milk; raw eggs; and farinaceous foods, such as Mellin's, Benger's, Allenbury's, Savory and Moore's, may in turn all be very useful; and in the latest stages we may have to be satisfied if we can get the patient to take small quantities of Valentine's beef-juice, Mosquera's beef-jelly, Brand's essence of beef, or similar articles.

Gall-Stones (Cholelithiasis).

A gall-stone is a friable mass of material which accumulates in the gall-bladder or bile passages from a variety of causes. Naunyn,[1] whose work on cholelithiasis is classical, found that the varieties of the stones are as follows: (1) Pure cholesterin stones. (2) Laminated cholesterin stones consisting of 90 per cent. of cholesterin with some bilirubin-calcium and calcium-carbonate. (3) Common gall-bladder stones, consisting of a mixture of cholesterin, bilirubin-calcium, calcium carbonate, albuminous and mucinoid material. The latter form the greater proportion of gall-stones. When removed from the gall-bladder, they are often so soft that they can be crushed into a greasy crumbling pulp, almost like a piece of clay. They consist of a central nucleus, and often

1 "Treatise on Cholelithiasis" (English translation, New Sydenham Society, 1896).

contain a cavity filled with a yellowish alkaline fluid. Their form and size varies, and they are frequently faceted. (4) Mixed bilirubin-calcium stones containing 25 per cent. or more or cholesterin, the remainder being bilirubin-calcium with small quantities of copper and iron. (5) Pure bilirubin-calcium stones, containing only traces of cholesterin. (6) Rarer forms: (*a*) Cholesterin gravel of the size of a grain of sand to a pea. With the exception of a foreign nucleus, they consist of pure cholesterin. (*b*) Calcareous stones, consisting largely of calcium carbonate with a little cholesterin and bilirubin. (*c*) Conglomerate stones. (*d*) Casts of the bile-ducts, consisting of pure bilirubin-calcium.

The origin of the constituents of gall-stones is disputed. As regards cholesterin, Naunyn says: "The cholesterin in the bile is 2·5 per cent., and pretty constant; it is independent of the proportion in the blood and the kind of food; nutritive derangements have no influence on the amount in the bile." The bile is an active poison to protoplasm, and some of the epithelial cells of the mucous membrane of the bile passages continually succumb to its action; it is very probable that an active shedding of these cells goes on in normal circumstances, and the débris mingles with the bile. The gall-bladder epithelium contains myelin globules which are essentially cholesteryl oleate; these, according to Adami, normally pass into the bile. In certain conditions of the gall-bladder this cholesterin is liberated in a solid state (Naunyn's amorphous cholesterin), and tends to collect in clumps; and in other conditions the precipitation of crystalline cholesterin occurs.

The view promulgated by Bramson that the precipitation of lime is due to an excess of this substance in the diet is not supported by experiments on animals. But cholesterin and lime-salts normal to the bile are held in solution by taurocholate and glycocholate of soda; and it is probable that precipitation of both substances may arise from a deficiency of these salts.

Gall-stones may form around nuclei, but the introduction of foreign bodies into the gall-bladder shows it is improbable that this is the common origin. Naunyn believed them to be formed as an aggregation of masses of amorphous cholesterin, etc. The surface of such a mass becomes clothed with a layer of bilirubin-calcium as thick and hard as a sparrow's egg-shell, and then the cholesterin begins to crystallize. It grows by disintegration of epithelial cells. The ultimate cause, most commonly, is catarrh of the mucous membrane of the bile passages set up by bacteria or some change in the chemical composition of the bile. The formation of gall-stones is favoured by age, sex, fashion of dress, luxurious living, gout, obesity, and alcohol.

Treatment consists of reduction of the catarrhal inflammation of the bile-ducts, and stimulation of the functions of the liver. Surgical treatment is necessary to remove stones in many cases, and will assist in the cure of cholelithiasis. Mayo Robson recommends surgical treatment—(1) In repeated attacks of biliary colic which

do not yield to medicinal treatment; (2) where there is evidence of cholangitis or suppuration; (3) empyema of the gall-bladder; (4) dropsy of the gall-bladder; (5) obstructive jaundice, if there is reason to think the common duct is occluded by gall-stones; (6) in acute peritonitis or perforating peritonitis starting in the region of the gall-bladder, where the previous history of the patient is suggestive of gall-stones.

Although the removal of a stone does not cure cholelithiasis, such an operation removes the obstruction to the course of the bile and one of the local causes of irritation, while rest in bed and careful dietary subsequent to the operation may go far towards curing the catarrh of the bile channels and gall-bladder. But the disordered functions of the liver, and in many cases the catarrh of the bile passages and the duodenum, can only be cured by a long course of dietetic and hygienic measures.

It is unnecessary to restrict the patient to any particular class of food; more depends on temperance in eating and drinking than on the kind of materials. But a few points have to be rigidly enforced. The food should be plain but plentiful. Excesses of all kinds favour the catarrh of the bile-ducts. If the dietary of the patient before treatment has been such as would favour the development of gastro-duodenal catarrh, it must be modified as in the treatment of that catarrh. A similar dietary to that for catarrh of the stomach or bowels is, on the whole, the best for gall-stones. The consumption of plenty of animal food is essential to provoke a secretion of bile, and prevent or assist in preventing biliary stasis. If the diet be restricted in amount, the secretion of bile will be diminished, and it may remain in the gall-bladder instead of passing into the duodenum. Stagnant bile tends to become inspissated by the absorption of water, and it may undergo changes in composition whereby it is disabled from retaining cholesterin and bile-salts in solution. Frequent and hearty meals, therefore, are recommended by most physicians to encourage the flow of bile: a good supper is said to be one of the most certain preventatives of gall-stones, providing the repast is of the right kind and quality. Although meat is recommended as favouring a good flow of bile, and preventing stagnation, it is essential that the meat shall be of such a character that it will not cause indigestion. Therefore pork, veal, sausages, hashed meat, pork pie, duck, goose, high game, herrings, mackerel, salmon, lobster, crab, mussels, etc., must be strictly avoided. It is equally essential that the formation of alimentary toxins be avoided as much as possible, in order to free the liver from an excess of work in destroying them.

Fat of all kinds is usually forbidden, although vegetable fats are considered not so injurious as animal fats. The patient should not eat the fat of meat, bacon, or ham; little or no butter should be taken; eggs should be limited to one a day; brain and liver would naturally be forbidden because they contain both fat and cholesterin; fatty dishes such as eel, mackerel, herrings, sprats, etc., must also be avoided; and all other fatty foods, substances cooked in fat,

rich cakes and puddings, suet dumplings, and puddings with boiled pastry crust. Fats are forbidden on the ground that they upset the alimentary organs; when taken in excess, they exercise no favourable action on the secretion of bile; on the other hand, they are often said to overtax the liver cells, and they are generally badly tolerated. The opinions of Halliburton and Michael Foster are given in the section on Jaundice. Burney Yeo [1] says the excretion of an excessive amount of cholesterin appears to be dependent to some extent on an excessive consumption of fats, and gives that as a reason for cutting down the supply. On the other hand, Binet [2] says that there is no need to cut down the supply of fat excepting in jaundice, or where there is a very insufficient supply of bile, the greater part of the consumed fat being absorbed by the chyle vessels (*lacteals*), and does not traverse the liver. He therefore considers it is legitimate to allow a certain quantity of fat in the food of most patients. But he makes a distinction between his cases, and absolutely forbids fat when there is no doubt that the liver is overtaxed and its cellular functions manifestly insufficient. The toleration of fat varies in different cases and according to the variety consumed. Only fats of low fusion-point should be allowed, such as butter and cream, and these must be free from taint or rancidity. In many cases there are positive reasons for recommending fat as a part of the diet. If two similar cases are treated, one with and the other without fat, it may be noticed that the patient to whom fat is allowed improves more rapidly, and the improvement is better maintained, than the other from whom fat is withheld. The reason for this, according to Binet, is because there is frequently a coexistent hyperchlorhydria and pain due to pyloric spasm. These are the cases in which fat does most good. The laxative effects of fat ought also to be of value in these cases. Olive-oil is often prescribed; it is digested better than fat meat, but is not borne so well as cream or butter. Olive-oil is frequently prescribed on the supposition that it will dissolve the gall-stones, or soften them, so that they will easily pass through the bile-ducts. It may be given in doses of one or two tablespoonfuls in hot milk at bedtime. It has been prescribed in large and smaller doses, but the reports on its effects are by no means uniform or satisfactory. Possibly this may be due to its administration in the wrong class of cases. Binet says the administration of fats should not be permitted except in the chronic stage, and when every trace of local or general infection after an acute inflammatory attack has passed off. In suitable cases he prescribes 60 to 100 grammes of butter or 200 to 300 grammes of cream in twenty-four hours, one-third of the amount to be taken three times a day at the end of the meal. The evening dose, he considers, secures a better flow of bile during the following night.

The carbohydrates may as a rule be taken in moderation. There is usually no reason why bread and potatoes should be limited;

[1] "Food in Health and Disease," p. 433.
[2] *Tribune Médicale*, 1910, x.

but it must be distinctly understood that a diet consisting of bread-and-butter and tea, or potatoes and a bit of bacon, or tiny pieces of meat, would be a most erroneous diet, and would favour duodenal and biliary catarrh. Sugar—that is, ordinary cane-sugar—should be eaten sparingly owing to its tendency to fermentation and to cause catarrh of the gastro-intestinal mucous membrane. All sweet dishes, therefore, should be taken in moderation, as well as jam, marmalade, and treacle. But golden syrup and substances containing maltose, dextrose, and dextrin, are equally nourishing, and are believed to be less injurious.

The patient must avoid pickles, spices, condiments, highly seasoned foods, and other articles which have been previously condemned as capable of causing hepatic hyperæmia and gastro-intestinal disorders.

Vegetables and fruits which are not very sweet may be allowed. Potatoes, cauliflower, cabbage, spinach, vegetable marrow, string or snap beans, lettuce, watercress, tomatoes, dandelion, endive, seakale, asparagus, artichokes, and other vegetables are useful. But turnips and swedes should only be taken in the form of purée, while peas, beans, lentils, and carrots should be forbidden because they contain phytosterin, which is a vegetable form of cholesterin. Jankau found that cholesterin in the food does not increase the excretion of cholesterin; nevertheless, it is better to leave it out. If stewed fruit is eaten, it should be sweetened with saccharin or dulcin; indigestible fruit and nuts must be avoided, especially nuts which contain much fat. But all easily digested vegetables and acid fruits are useful, because the organic acids are changed in the organism into alkaline carbonates, and promote a flow of thin bile. The precipitation of cholesterin is favoured by a deficiency in the alkalinity of the bile as shown by Thénard, who considered such a condition of the bile had been traced to the too exclusive use of animal food. This probably is the basis for the suggestion made by some physicians that the consumption of animal foods should be restricted. On the other hand, it is known that the secretion of bile is promoted by abundant animal food, and diminished by a diet consisting of fat and farinaceous foods. Therefore it may be concluded that good food, in which animal substances figure prominently, is the proper treatment for gall-stones, providing too much fat is not eaten; but a diet consisting chiefly of bread-and-butter and vegetables is bad treatment for gall-stones.

The patient should drink plenty of liquids with the food and between the meals. Most people of this class drink too little fluid, which tends to inspissation of bile and stagnation in the bile channels; the formation of gall-stones is thus favoured, just as other passages which are never flushed tend to become choked up by deposits of solid matter. The patient, therefore, must be encouraged to take plenty of liquids. They may consist of tea, coffee, cocoa made from the nibs, buttermilk, whey, plain water, the alkaline waters (soda-water, Apollinaris, Perrier, Selters, Vichy), and plain or aerated distilled water (*e.g.*, Salutaris). A tumblerful of

hot water with Carlsbad salts or phosphate of soda should be drunk each morning while dressing. Hock, Moselle, or light Rhine wine, or even good Burgundy, diluted with the foregoing waters, is permissible with lunch or dinner. The amount of liquids consumed during the day should be not less than three pints, and may advantageously be increased to 4 pints. Sweet wines, and especially champagne, should be forbidden.

The diet, therefore, may be selected from the following articles:

Lean Meat.—Beef steak, undercut of beef, sirloin of beef, shoulder or leg of mutton, tongue, lean ham.

Fish.—All kinds which contain not more than 2 per cent. of fat (see list, pp. 12-13).

Poultry.—Boiled fowl, chicken, capon; pheasant, partridge, and other game, unless it is very high.

Soup.—Clear soup (free from fat), vegetable soup, milk soup, bone soup (free from fat and thickening).

Jelly.—Plain and unsweetened savoury jelly, and other jellies which are sweetened with saccharin.

Eggs.—One whole egg daily. Th restriction on eggs applies to the yolk only, as the white is free from cholesterin and fat.

Fat.—Butter up to 1 ounce daily in ordinary cases, more being allowed if there is hyperchlorhydria. Milk and cream are allowed in small quantities. The amount of cream usually taken in tea or coffee is permissible; but an excess of cream in trifles, "creams," or cream with fruit would be injurious. The total amount of "whole" milk consumed should not exceed ½ pint daily, providing enough nitrogenous food can be taken in other forms. Skim milk is less injurious than whole milk because of its freedom from fat.

Farinaceous Foods.—Bread, wholemeal bread, dry toast, rusks, zwiebach, biscuits (crackers), oatmeal, barley, rye-meal, buckwheat, arrowroot, sago, rice, tapioca, semolina, macaroni, vermicelli, noodles, spaghetti.

Vegetables and Fruit.—As stated above.

The remaining points include various hygienic measures Perhaps the most important is regular attention to the bowels. Aperients are necessary, and they should be such as will increase the secretion of bile and dilute it, promote a regular discharge of fæces, keep the mucous membrane clean, assist in curing catarrh of the alimentary canal, and at the same time relieve portal congestion. These points are best gained by taking, before breakfast, such waters as contain sodium sulphate and bicarbonate—*e.g.*, Carlsbad and Marienbad waters. The quantity usually prescribed is half a tumblerful of the water with an equal amount of plain hot water. It is usually stated that the bottled waters have the same beneficial effect as those taken fresh from the spring. This is rendered doubtful by the recent knowledge of the action of ions of mineral salts and their radio-activity. At any rate, it has been demonstrated that waters lose a considerable proportion of their radio-activity when bottled for any length of time. But in the inability of the patient to go to the spa, even the bottled water is better than nothing. It stimulates the peristaltic activity of the alimentary canal, and reflexly that of the biliary passages, and promotes the circulation throughout the portal system. By clearing the alimentary canal of bile salts, which are normally re-

absorbed and utilized again, the liver is stimulated to produce more bile for the digestive operations. The injection of a large quantity of plain hot water into the rectum has a similar effect in clearing the bowels, is preferred by many people, and, in the absence of the proper water, may be recommended. It is, however, considered that the salts in the spa waters do more than clear the bowels of effete material. It is believed that the natural aperient waters act by stimulating the muscular coats of the gall-bladder and bile-ducts, and thereby assist in the evacuation of gall-stones. It is often recommended that patients be sent to Carlsbad, Marienbad, Kissingen, Brides, Vichy, and other Continental resorts for treatment, where, of course, the treatment is partly dietetic; and it cannot be denied that the treatment is valuable. But patients should be warned that calculi, even some of large size, are sometimes eliminated during the treatment, and consequently severe attacks of biliary colic and jaundice may occur. It is questionable whether better results are obtained at these resorts than could be obtained at home if people would submit to the same rigorous treatment. There is, however, quite a difficulty in persuading some people to follow out a course of treatment at home which they will cheerfully travel a thousand miles to follow out in a fashionable resort.

The sulphurous waters have a very beneficial effect on the liver, and many people find great relief from a course of treatment at Harrogate and other places in Great Britain, where the treatment is carried out on the same lines as at the Continental spas.

It is important that the exercise of such patients should be regulated. Walking exercise is probably the best mode for the average gall-stone patient. It encourages respiration, stimulates the circulation, promotes the secretion of bile, assists digestion and the action of the bowels. Gall-stones are promoted by stagnation of the bile. The object of exercise is to prevent that stagnation. Persons who are most subject to gall-stones are often languid, easily fatigued, and take practically no exercise Such people must be encouraged to exercise themselves in a rational mannar. It is possible that they will do this more zealously if they are told to practice various exercises. Deep-breathing exercises are useful by promoting a flow of bile; they should be practised in such a manner that the liver gets a good squeeze between the diaphragm and the abdominal muscles. Exercises with a pair of light dumb-bells promote deeper respirations and encourage the circulation. Tennis, badminton, golf, and riding on horseback are useful. Many patients have got past taking these exercises, or are otherwise unable to indulge in them. But all persons can do walking and breathing exercises if they will do so; and the benefit to be derived from them should be fully impressed upon the patient. Gall-stone patients must not wear tight corsets or belts, because they impede respiration and favour stagnation of the bile; on the other hand, it is essential for them to wear warm clothing around the thorax and abdomen.

CHAPTER XII

DISEASES OF THE URINARY SYSTEM

When passing through the body, our nitrogenous foods are converted into urea and allied substances, carbonic acid, and water. Many proteins and fats contain phosphorus and sulphur, which are oxidized to phosphates and sulphates. The organic acids are converted into alkaline carbonates and water. The mineral acids and their salts are excreted chiefly as carbonates, sulphates, phosphates, and chlorides. The waste matters of the body therefore consist of urea and its allies, carbonic acid, salts, and water. The liver has been called the great depurating organ of the body, and there can be no doubt the body depends on the liver to put the nitrogenous waste matters into a proper condition for easy excretion. But the kidneys occupy the first place in the excretion of nitrogenous bodies, most of the salts, and a great proportion of the water. Good metabolism therefore depends on healthy kidneys. But the kidneys alone are not responsible for all the deviations from metabolism which occur in regard to the excreted bodies, nor in respect of the abnormal conditions of the urine observed in various states of the organism.

Urinary Deposits—Gravel and Stones.

Under certain conditions not yet thoroughly understood, the urine is unable to retain some portion of its contents in solution, and there is the formation of a deposit, gravel, or stone. The nature and composition of deposits and concretions differ widely. But certain characters are associated with stones or gravel having a fairly well-known composition. It is usually stated that renal calculi consist most frequently of uric acid or urates; but others consist of mixed urates and calcium oxalate in layers; and others, again, of calcium phosphate or triple phosphate. Professor Moore of Liverpool,[1] however, made an extended analysis of twenty-four calculi which shows that in this series, at any rate, the predominant constituent of most calculi is calcium oxalate (see table, p. 388).

The result of these analyses led Professor Moore to conclude that the significance of uric acid and urates in the formation and composition of calculi has been overestimated, that calcium oxalate is the primary constituent of stones; and calcium oxalate, calcium phosphate, and calcium urate are the commonest components.

[1] Analyses by Professor James Moore, *Brit. Med. Jour.*, 1911, i. 739.

The formation of stones and gravel is predisposed to by a defect of metabolism leading to the formation of oxalic acid, uric acid, phosphoric acid, and so forth, which unite to form salts with the earthy bases. If we suppose that a concretion starts as calcium oxalate, the predisposing cause being a faulty metabolism which causes the very insoluble calcium oxalate to be excreted in amount larger than can be held in solution, and if we take it that this growing concretion of calcium oxalate is nowadays usually removed by surgical interference before it has grown to such a size that it induces secondary changes in the urine and deposition of calcium urate, then we can explain the results obtained in the analyses below.

THE COMPOSITION OF CALCULI (PER CENT.).

No.	Seat of Origin.	Moisture.	Calcium Oxalate.	Calcium Phosphate.	Uric Acid.	Total Nitrogen.	Total Nitrogen calculated as Uric Acid.
1	Kidney ..	2·0	69·1	1·7	9·9	3·9	11·9
2	,, ..	17·9	87·3	5·8	4·2	2·6	7·8
3	,, ..	3·5	86·7	7·4	6·9	2·6	8·0
4	,, ..	6·8	99·0	nil	1·7	2·3	7·0
5	,, ..	2·7	99·7	nil	nil	1·3	3·9
6	Ureter ..	2·4	85·1	14·5	1·5	0·9	2·8
7	Bladder ..	6·5	nil	nil	97·5	—	—
8	Kidney ..	13·2	31·5	60·9	6·7	7·0	21·0
9	,, ..	1·5	79·6	1·9	10·6	4·6	14·0
10	,, ..	1·9	90·0	8·7	4·0	1·2	3·6
11	Ureter ..	1·9	94·4	nil	2·5	2·2	6·8
12	Bladder ..	9·0	nil	nil	—	32·8	98·5
13	Kidney ..	2·5	86·1	6·6	1·8	1·0	3·0
14	,, ..	2·1	84·7	13·0	3·7	1·3	4·0
15	,, ..	12·8	51·7	40·4	2·4	1·4	4·2
16	,, ..	1·7	93·8	nil	5·8	0·7	2·2
17	Ureter ..	3·9	41·3	47·8	—	1·2	3·8
18	,, ..	15·7	16·8	69·3	9·6	2·3	6·9
19	Kidney ..	2·6	81·0	4·1	11·9	5·2	15·8
20	Ureter ..	3·9	31·6	63·5	—	1·0	3·1
21	Kidney ..	9·3	95·0	nil	—	1·2	3·8
22	Ureter ..	11·6	32·5	51·7	—	3·6	11·0
23	,, ..	3·7	90·4	3·8	5·0	—	—
24	Prostate ..	—	96·1	nil	nil	—	—

"If we take it that this calcium oxalate concretion goes on growing, causing irritation and infection, and giving a rough foreign surface in the kidney, pelvis, or urinary bladder, we may then get a secondary deposit of calcium phosphates or acid urates, simply because these are the least soluble constituents of the urine, and for reasons in no wise connected with the original formation of the stone. Such a process of reasoning would explain the urate and phosphate formations, and the deposition of the outer rings on the large renal concretions of former days. . . . It is of little consequence whether

a degenerated kidney cell or a micro-organism is the nidus around which the renal calculus starts to grow, or whether it starts spontaneously, since it is only a certain type of disordered metabolism, causing the production of insoluble salts of calcium, which can keep it growing. In the presence of this disordered metabolism there will be gravel in the urine or stone in the kidney; in its absence, whether renal infection be present or absent, there can be no gravel and no renal calculi. To classify calculi into primary and secondary in the usual manner only causes mystification by exchanging cause and effect. Gravel and renal calculi more often lead to infection of the kidney than primary kidney affection leads to renal calculi; if, indeed, the latter ever occurs. The presence of micro-organisms in renal calculi is the absurdest evidence that the stone arose from renal infection." [1]

In addition to the faulty metabolism, there are certain circumstances which predispose to stone formation. One of these is the concentration of the urine, whereby a tendency to the deposition of insoluble salts in induced. When little water is taken with the food while a considerable amount leaves the body by the lungs and skin, the urine diminishes in quantity, and is so charged with solids that the slightest disturbance may lead to a deposition. If a little of the water from such concentrated urine is reabsorbed at any point in the urinary passages, the remainder is no longer able to retain all the solids in solution, and some is at once precipitated in the form of gravel, and tends to the formation of concretions. A great drain of water from the system, by diarrhœa, profuse perspiration, or anything which lowers the blood-pressure, favours the production of gravel and stone. The quantity of urine depends on the blood-pressure, for with a decrease in the mass of blood, and corresponding lowering of the pressure, there will be a diminution of water in the urine. But the waste of the tissues is going on as before; and if the waste is passed out through the kidneys, it must be as a concentrated solution; and the more concentrated the urine the greater is the danger that solids will be deposited in a crystalline form and tend to the formation of calculi. It has been observed that the formation of calculi in animals is practically unknown if they are kept at pasture in summer, or fed liberally on roots, potatoes, swedes, pumpkins, apples, or ensilage in winter, because these foods are moist, and the urine does not become concentrated. In cattle, calculi and gravel form almost essentially a winter disease, which is confined to animals fed with dry fodder and denied succulent rations. Therefore an abundance of water in the food tends to prevent, and a deficiency to promote, calculus formation.

The presence of a large quantity of lime salts in the water which is consumed favours concentration of the urine. If the water contains 20 to 30 grains of carbonate or sulphate of lime per gallon—a not unusual quantity—it must contribute a large addition to the salts

[1] Moore, *Brit. Med. Jour.*, 1911, i. 738-739.

of the blood and urine. Such salts are not all utilized in the body, but are excreted at once in a large measure. It is notorious that stone and gravel are prevalent, not only in man, but in herbivora, in the limestone and calcareous regions of America and Europe. This has been denied by various authorities, but their denial must be substantiated by statistics before it can be accepted. It does not follow, of course, that an abundance of lime in the water is the main cause of calculi, since other poisons are operative in the production of goitre in man and animals living in the same regions, and these probably contribute to the causation of calculi. An excess of lime can scarcely fail to assist the saturation of the urine, and thereby tend to the precipitation of urinary solids. The results of feeding cattle with a generous ration of material containing phosphate of lime gives additional force to this view. The liberal allowance of wheat-bran, given with the idea of increasing bone and improving "condition," has resulted in the formation of urinary calculi. This may be appreciated when it is stated that the ash of wheat-grain is only 3 per cent., that of wheat-bran 7·3 per cent.; in the former case 46·38 per cent. of the ash is phosphoric acid, and in the latter 50 per cent.

THE PROPORTION OF PHOSPHORIC ACID IN VEGETABLE FOODS (PER CENT.).

	Total Nitrogenous.	Total Ash.	Phosphoric Acid in the Ash.	Phosphoric Acid in Entire Food.
Wheat-bran	24·1	7·3	50·00	3·6500
Wheat grain	14·3	3·0	46·38	1·3910
Oats ,,	21·3	2·5	26·50	·6625
Barley ,,	15·1	3·1	39·60	1·2276
Rye ,,	12·3	1·6	39·90	·6384
Beans ..	30·5	3·1	31·90	·9864
Peas ..	23·5	2·7	34·80	·9570

It is therefore evident that wheat-bran contains three times as much phosphoric acid as the entire grain, and four times as much as there is in oats, beans, peas, and rye; so that an excessive consumption of foods containing bran would readily overcharge the urine with phosphates. Again, wheat-bran contains much more albuminoid and other nitrogenous substances than the entire grain of wheat or other cereals, whence it follows that the urine may contain an excess of urea and other nitrogenous waste products which bring it near to the point of saturation. The above table shows that, with the exception of oats, none of the cereals contain more than two-thirds of the total nitrogenous materials of bran, while rye and maize only contain about half as much. Even oats, which contain the most digestible albuminoids and those most easily transformed into urea, only contain two-thirds the amount of that in bran.

The presence of magnesia in the food or water also favours the formation of calculi. The explanation of this is that while the phosphate of magnesia is soluble in water, the compound phosphate of ammonia and magnesia is insoluble; and if at any time ammonia is introduced into the urine containing phosphate of magnesia, there is instantly formed the insoluble ammonio-magnesium phosphate, which is deposited in a solid form. The common source of ammonia in the urine is the decomposition of urea due to fermentation. But in order to produce decomposition an enzyme is necessary, and this is provided by bacteria which gain admission to the urinary passages. The precipitation of magnesium phosphate is favoured also by the presence of colloid materials arising from catarrh or inflammation of the mucous membrane.

A somewhat less common constituent of calculi is calcium carbonate. It is derived from food and water, and from carbonic acid gas arising from the decomposition of organic acids. The organic acids of the food are resolved into alkaline carbonates, but some of them are completely decomposed into CO_2 and water; the CO_2 unites with lime in the blood and forms calcium carbonate, and some passes into the urine. Calcium carbonate is soluble in water which contains free CO_2 in solution, but it is precipitated when this gas is withdrawn. It is therefore only necessary to have in the urine sufficient lime or other available base to unite with the free CO_2, which holds most of the calcium carbonate in solution, to cause its immediate precipitation in a solid crystalloid form.

The calcium oxalate of calculi arises in the organism in a similar manner. The lime is derived from the food or water, and the oxalic acid is chiefly a product of the transformation of the organic acids or carbohydrates of the food. Some oxalic acid may enter the system preformed in various foods. But in consequence of some defect in metabolism which causes insufficient oxidation in the tissues, there is a failure in the process of the transformation of organic acids or carbohydrates, or both, into CO_2 and water. Normally, the oxidation of these materials is complete, and carbonic acid is the final product of decomposition; but when less oxygen is furnished to the body owing to diseases of the lungs or nervous system, which lessen the activity of breathing, or insufficient exercise, which also leads to deficient oxidation, or a deficiency of the intracellular enzymes by which the oxidative processes are carried out, then oxalic acid may be produced, and if it comes into contact with lime, it is precipitated as calcium oxalate. The presence of calcium oxalate as an abundant and frequent constituent of calculi opens up a field for investigation in metabolism which has not yet been thoroughly explored. It points unmistakably to embarrassed oxidation, or to conditions attending its formation in which oxygen is deficient, or there is an insufficiency of the enzymes, now believed to be of importance in the transformation of proteins, fats, and carbohydrates. Moore says: "The association of calcium oxalate,

calcium phosphate, and calcium urate as the three commonest components in this series of calculi (table given above) is most interesting; and since two of the acids concerned are associated with the incomplete oxidation of proteins and carbohydrates, and the third (phosphoric acid) is always excreted in greater abundance under conditions of diminished oxidation, the suggestion is awakened that calculi are found usually in conditions of reduced oxidation associated possibly with disordered calcium nutrition or metabolism. . . . The subjects of renal calculi and gout show a preponderance of individuals of sedentary occupation or of inactive habits of body. The natural disposition and bent of such people is against exercise and the increased oxidation which it brings, and affairs are made worse by their disposition to pile on more fuel instead of lessening the intake, and so to still further check the rate of the oxidative processes. . . . But the deposition of insoluble calcium salts, under conditions of diminished oxidation, in the kidneys is not an isolated and peculiar occurrence, but can be linked up with the formation of many types of insoluble calcareous deposits in other situations in the body, which at first sight are apparently quite different in type and origin." [1] These include the calcification of cartilage, the increasing brittleness of the bones in advanced age, the formation of chalk stones, the calcification of tuberculous foci, and the arterio-sclerosis and calcification of arteries.

But other conditions enter into the formation of stones and gravel. A high density of the urine from an excess of solids or deficiency of water may exist for a long time without the formation of gravel or stones. If, however, there arises from any cause the presence of colloidal material, such as mucus, blood, albumin, casts, or epithelial cells, it may act as an exciting cause of the concretion. These substances will not only determine the deposition of crystallizable salts from a strong solution, but they may determine the precipitation of such salts in the form of urinary deposits consisting of crystalline or minute spheroidal masses, and they form calculi by accretion. In the case of stones formed by chemical reaction and without the intervention of colloids, the salts are deposited in the form of sharply defined angular crystals; hence the rough, jagged crystals of calcium oxalate and ammonio-magnesium phosphate. The action of colloids in causing the precipitation of dissolved salts has been shown by Rainey and Ord to be intensified by moderate heat; the temperature of the kidneys and bladder is a favourable condition. When colloids undergo decomposition, they are particularly active in producing such precipitation; and herein lies the importance of bacteria as a factor in calculus-formation. A catarrhal inflammation of the bladder, due to bacteria, results in the formation of mucus or pus, and the subsequent decomposition of mucus and urea may determine the presence of the uncrystallizable colloid that is effective in the precipitation of salts and the formation of gravel or calculus.

[1] *Loc. cit.*

Treatment of Calculus.—Although the most scientific treatment of a calculus is its removal from the body by a surgical procedure, there is much to be done by other means, and many cases of gravel are cured by hygienic and dietetic management. If a calculus is immersed in a liquid of a lower specific gravity than its own, or that in which it was formed, some of the more soluble constituents tend to dissolve out, the density of the body and its cohesion at all points is lowered, and its disintegration and expulsion favoured. Therefore the consumption of a large quantity of water daily, persistently and without intermission, will cause a free secretion of urine of a low specific gravity, and will tend to obviate the catarrhal condition of the urinary mucous membrane and the continued deposit and accretion which occur when the urine is more highly concentrated. It will likewise press a renal stone downwards towards the bladder, favour the crumbling of the stone, the disintegration of a considerable portion of it, and the expulsion of detritus. This is what happens during a prolonged stay at the source of many mineral waters, and is the result to be looked for from spa treatment. Therefore, a prolonged stay at Vittel, Contrexéville, and other places renowned for the cure of gravel and stone may be recommended But there are many patients who, for various reasons, are unable to spend money and time on treatment at a fashionable resort. These should be recommended to drink large quantities of ordinary water in their own home. The chief constituent in mineral waters is water; and this is the solvent of gravel and calculi. Doubtless the particular water of fashionable spas is better than ordinary spring or river water. But when these are unobtainable, the patient should follow out, in his own home, the course recommended at the spas. Soft water or rain water is a better solvent than hard or spring water. Better still is distilled water, and especially the commercial forms, such as Salutaris or Puralis, and almost equally good are those of low mineralization, such as Perrier water. If the patient will consume the same quantity of water at home as he would have to do under medical supervision at the spa, if he will take it at the same temperature, at the same intervals, or distributed throughout the day in the same manner, and follow out the same régime with regard to food and exercise, he will probably benefit by the treatment nearly as much as he would by a visit to the spa.

The further treatment of the urinary deposits and calculi is detailed below under special headings.

Uratic Deposits—Uric Acid Gravel and Calculus.—Increased excretion of uric acid may be due to—(1) Increased consumption of animal food; (2) diminution of the oxidation processes, such as occurs in people of sedentary habits; (3) leucocythæmia. Leucocytes contain nuclein, which decomposes into nucleic acid, and finally into purin bodies—adenin, guanin, and hypoxanthin—which are closely related to uric acid. A great increase in the proportion of white corpuscles of the blood naturally leads to the

formation of such purin bodies which are normally reduced by oxidation to urea, but may only reach the stage of uric acid.

Excess of urates and lithates of ammonia and soda are deposited in the urine owing to the following causes: (1) Rapid waste of the tissues—*e.g.*, in febrile diseases; (2) excessive consumption of proteins; (3) congestion of the kidneys; (4) obstruction of the perspiration—*e.g.*, a chill of the cutaneous surface; (5) indigestion and faulty assimilation of food; (6) imperfect oxidation in the tissues.

Uric acid gravel, uric acidæmia, and lithæmia therefore arise from an excessive consumption of proteins, defective nitrogenous metabolism, imperfect oxidation in the tissues, diseases of the liver and spleen, leucocythæmia, and imperfect elimination of the waste products.

The formation of a uric acid calculus does not depend solely on the amount of uric acid in the urine, for the urine that deposits uric acid is often dilute. It may, however, contain an excess of other urinary salts, especially calcium oxalate or phosphate, whose presence influences the formation of the calculus. But it is considered by Rainey and Ord, and other authorities, that a slight pyelitis is equally necessary to provide colloid material (mucus, pus, albumin, or blood) to cement the particles together.

The **diet** is a very important element in the treatment. Uric acid is one of the products of metabolism which necessarily goes on even during starvation. Its formation and excretion cannot be prevented. But we can limit the amount of uric acid derivable from the food, do something to encourage metabolism, and check the deposition of uric acid in the urinary passages by influencing the reaction of the urine. Urine which is very acid is more likely to deposit uric acid than urine which is less acid. The salines of the blood and urine are deficient in lithæmia and uric acid gravel. Therefore the subject of these ailments should consume foods which are known to be rich in salines, and to eat less of those which do not contain them. Stone rarely affects the children of the well-to-do, but is far more common in those of the poor. Roberts, who devoted many years to the study of the subject, considered the immunity of the rich was due to their consuming more meat, which contains the salines of the blood; and the reason why the poor are so often afflicted by it is because they live more on cereals, which are poor in salines, and he pointed out that stone is common among the rice-eating Hindoos. He therefore prescribed a dietary consisting of animal food—meat, fish, fowl, game, oysters, eggs, cheese, and milk, with an abundance of fresh vegetables. Potatoes, rice, sago, bread, and other farinaceous foods should be eaten sparingly, because of their deficiency in salines. But the amount of animal food consumed should not exceed the normal requirements of the body. Indeed, Klemperer and other authorities believe it is better to prescribe a **purin-free dietary**. They recommend the patient to consume milk, cheese, white bread, fruit, and vegetables, to take ordinary animal food in great moderation, and **avoid** all foods containing substances capable of forming uric acid, especially red meat,

venison, smoked meat, fish, liver, kidneys, sweetbread, tea, coffee, and cocoa, and substances containing oxalic acid, such as sorrel and tomatoes, and acid beverages. Haig,[1] who is one of the greatest exponents of the purin-free dietary, formed a different opinion of the inhabitants of the North-West Province of India. He says: "Among the poorly nourished rice-eating population, stone is rare. Among the wheat-eating, meat-eating, and generally better-fed provinces it is frequent; and in these provinces it is especially common among the men and boys, rare among the women and girls; and this is largely due to the diet, for the men feed best and the boys with them, the women have their leavings, and the girls what they can get, the last-named being very little thought of and badly fed." Haig goes on to say this is simple enough; "those have most stone who eat most meat, and thus introduce uric acid as well." It is quite possible to have an excess of uric acid in the body as the result of the constant consumption of nitrogen in excess of the physiological requirement, and this is the amount required to produce $3\frac{1}{2}$ grains of urea per pound of body-weight per day. It is, however, in my opinion, sufficient to limit the consumption of protein to the needs of the body, and to choose the flesh foods which contain the least amount of purins rather than to exclude animal foods from the diet. It should not be forgotten that caffein, thein, and theobromin are purin bodies; and that vegetable foods which contain a large amount of nuclein, such as peas, beans, lentils, onions, asparagus, and other vegetables, contribute largely to the uric acid manufactured in the body. If the processes of metabolism are healthy and the oxidative processes normal, the uric acid will be transformed into urea. But in people who suffer from uric acid gravel these processes are not normal. It is therefore proper to inquire into the food-habits of the patient. People in easy circumstances eat a good deal more meat than they require, including sweetbreads, devilled kidneys, liver, beef steak, game, salmon, venison, and gravy made from spleen or other uric-acid-containing substances. Vegetarians, on the other hand, eat freely of leguminous foods containing nuclein, which is reduced to uric acid. When, therefore, we find that the patient indulges in an excess of animal food, let him be put upon a diet of tripe, boiled mutton, rabbit, cod, plaice, halibut, *fat* ham or bacon and eggs, with butter, milk, cheese, *white* bread, macaroni, plenty of green vegetables and salads, fresh fruit, and a small amount of potatoes. If he is a vegetarian, put him on a diet similar to the above, but he must eat sparingly of rice and potatoes, which are deficient in salines.

The patient should not go too many hours without a meal. The urine becomes alkaline after a meal (*the alkaline wave*), but acid during the metabolism of food (*the acid wave*). All the food should be well *salted*. The value of common salt as a preventative or cure of gravel and stone is evidenced by the fact that sailors and other

[1] "Uric Acid," p. 558.

men who live largely on salted meat or fish are rarely troubled by these affections. The same remark applies to people who constantly drink brackish waters. Another explanation of the fact that salted meat and fish do not cause gravel or stone is that by curing these foods in this manner some of the soluble nitrogenous matters are lost by the abstraction of meat juice containing albumin, meat bases, and purin bodies, and consequently such foods contain less protein and purin bodies than fresh meat or fish does.

With regard to beverages, milk is useful because it is practically purin-free, but it should not be forgotten that it is a nitrogenous food, and the amount of protein taken in this way must be reckoned in the account. *Weak* tea is allowable, with plenty of milk or cream. Malt liquors are prohibited. Alcohol in any form should be forbidden, because it is believed to increase the excretion of uric acid by interfering with oxidation. Opinions differ on this point. Klemperer says it is uncertain whether alcohol has any influence over the excretion of uric acid. In certain cases a little hock, Moselle, Rhine wine, Volnay, or other wine of a light character, may be allowed, providing it is diluted with an alkaline water such as Apollinaris, Perrier, Evian, Vittel, Contrexéville, or Martigny water. The effervescent lithia, potash, or soda-water, may be taken *ad libitum*, and it may be pointed out that carbonate of lithia has six times the solvent power of bicarbonate of soda over uric acid.

The acidity of the urine must be kept down below a certain level. Roberts showed that uric acid normally exists in the urine in the form of quadriurates; and the first step in the precipitation of uric acid consists in breaking up the quadriurate into biurate and setting some of the uric acid free, which, being but slightly soluble in water, is readily precipitated while the biurate remains in solution. Vaughan Harley asks: " If this view is correct, what prevents such precipitation from always occurring? It appears to be the sulphates, chlorides, phosphates, and colouring matter that do this, but the potassium salts appear to act more powerfully than the sodium or ammonium salts, while a fixed alkali entirely prevents the change from taking place." The acidity of normal urine is due to acid phosphate of soda derived from the blood; and it is supposed that the basic sodium phosphate is converted into acid sodium phosphate by the uric acid, hippuric, sulphuric, and other acids taking away part of the sodium, and the basic sodium phosphate (Na_2HPO_4) thereby becomes acid sodium phosphate (NaH_2PO_4). The appearance of a precipitate of uric acid can only rise from two causes: (1) An excessive formation of uric acid, whereby the solvent power of the urine is insufficient to keep the increased amount of uric acid in solution; or (2) a diminution in the quantity of the natural solvents of uric acid, which leads to its precipitation, although the quantity of uric acid is normal or less than normal. It is advisable, therefore, that the solvent action of the urine be aided by various means. The most obvious means is by dilution

of the urine with water, and the patient should be encouraged to drink freely. But 1 gramme of uric acid requires 7 litres of water for its solution at the temperature of the body; therefore it is impossible to increase the amount sufficiently to prevent precipitation by water alone. But the saline and alkaline waters are beneficial not only by promoting diuresis and dilution of the urine, but by bringing to the urine those salts which reduce its acidity and increase its solvent power over the uric acid. The patient should drink not less than 3 pints of fluids a day. A tumblerful of alkaline water should be taken while dressing in the morning, at noon, about 5 p.m., and at bedtime. The waters of Vichy, Ems, Vittel, Vals, Tarasp, Royat, Contrexéville, Neuenahr, Apollinaris, and Evian are suitable for the purpose. The changes may be rung on these waters, each in turn being taken for two or three weeks. Fiessinger says a season should be passed at Evian or Vittel, but the waters of Vichy and similar places should be avoided lest too great an alkalinization of the urine should lead to the precipitation of phosphates, thereby increasing the size of uric acid gravel and leading to the formation of large calculi. If the patient is unable to afford a prolonged course of these waters, an alkaline powder which can be taken in ordinary water must be prescribed. The most suitable is a combination of sodium chloride, sodium bicarbonate, and potassium bicarbonate in equal parts. A small teaspoonful of the powder in a tumblerful of hot water at the times previously stated will dilute the urine, reduce its acidity, and act as a diuretic. The greatest danger of precipitation of uric acid occurs during sleep or in the early hours of the morning—that is, at the period most remote from the last meal, metabolism still progressing, and *the acid wave being in existence.* If the patient is awake in the night, he may reduce the acidity of the urine by taking an alkaline drink, for which purpose a dose of the above powder or one of the alkaline waters may be taken in milk. Roberts said: "By a prompt resort to alkaline remedies patients may protect themselves effectually against fresh uric acid concretions, and save themselves a world of pain and danger."

The digestive organs and liver must be kept in order to promote the transformation of uric acid and other purin bodies into urea. An occasional dose of Pullna, Marienbad, or Carlsbad water, may help in these respects. But drastic purgatives must be avoided, because they tend to concentration of the urine. Exercise should be regularly taken, but the greatest care must be taken in this respect. Persons who perspire freely must not indulge in excessive physical exercises, because it tends to concentrate the urine and cause a precipitation of urates and uric acid. In this respect the treatment of uric acid gravel differs from that of gout. Levison found that horse-riding increased the amount of uric acid in his urine from 0·6 to 0·981, or even 1·098 grammes per diem. Excessive muscular exercise also tends to leucocytosis, and therefore to the destruction of nuclein and increase of uric acid.

Oxaluria—Oxalic Acid Gravel and Stone.—Oxalic acid occurs in the urine in the form of dumb-bell or envelope (octahedral) crystals of oxalate of lime. A substance known as "oxaluric acid" ($C_3H_4N_2O_4$) occurs in normal urine in small quantities in combination with ammonia. Oxalic acid arises from the decomposition of this substance, and combines with calcium salts to form oxalate of lime. The amount of oxalic acid normally formed in the metabolism of the tissues is very small; and the great bulk of acid excreted in the urine in the form of oxalates is derived from the food or from the products of its decomposition. But the amount of oxalic acid is increased in some forms of faulty metabolism, and especially from a perverted metabolism of carbohydrates, which is the chief cause of endogenous oxaluria. But the exogenous oxalic acid is increased by the consumption of certain foods. It is said to arise from a vegetarian diet; but it also arises from all foods containing oxalates and fruits containing *citric acid*. Quantities of calcium oxalate have been found in the urine after the consumption of tomatoes, rhubarb stalks, sorrel, sheep-sorrel, and other vegetables and fruit. Even with normal calcium metabolism, if oxalic, phosphoric, or uric acid, begins to be formed in increased amounts, it may be expected that they will be deposited as calcium salts. At the same time, there is little doubt that, in the case of deposition of acids from such dilute solutions as are present in the body fluids, any concentration of the kation—*calcium*—will increase the tendency to precipitation and cause an increased deposit. When recommending a diet after the removal of calculi containing calcium salts, it is rational to interdict or diminish foods rich in calcium, such as gelatin, milk, oatmeal, entire wheatmeal, and some other vegetables. Oxaluria also occurs sometimes after the too free use of aerated waters, sparkling wines, such as champagne, sparkling hock, or Moselle, and malt liquors. Malt liquors nearly all contain appreciable quantities of calcium salts, which are naturally present in the water used for brewing or added for the purpose of making the water suitable for the purposes of the brewer. Stout and porter, being made with a softer water, contain less lime, and therefore are less deleterious than ale or beer. All heavy wines undergo the process of "plastering" to remove undesirable ingredients, but they obtain thereby an appreciable quantity of calcium salts. Being also rich in alcohol, these wines decrease the rate of oxidation in the tissues, and tend towards that defective metabolism which results in the formation of an increased amount of oxalates and urates.

But oxaluria is sometimes due neither to the presence of oxalates and citrates in the food, nor to the decomposition of urine, but to some disturbance of the metabolism. Oxalic acid may be formed in the stomach in hypochlorhydria and dilatation. But this only accounts for very few cases. The formation of large quantities of oxalic acid is due to the consumption of food in excess of physiological requirements, or the ability to metabolize it, oxalic acid and

uric acid being produced instead of urea. It often occurs in persons who enjoy the pleasures of the table. Individuals who become fat with good living are healthier and more robust than those who do not become fat in the same circumstances, and especially more so than those who lose fat. While the former suffer from inconvenience due to corpulence, the latter complain of all kinds of distresses usually ascribed to portal obstruction, hæmorrhoids, gout, catarrh of the alimentary canal, etc. This renders it probable that, when there is a disproportion between the supply and demand, and the excess is not removed by the formation of fat, the products of metabolism are modified, and the system is overloaded with abnormal waste materials. After a long continuance of such disturbed metabolism, with indigestion, melancholy, perhaps pharyngeal and bronchial catarrh, or pains in the joints, first one group of symptoms and then another becoming prominent, such persons become pale, thin, feeble, sleepless, and appear to be threatened with some grave affection. Then an examination of the urine reveals the presence of calcium oxalate crystals, and other evidences of abnormal metabolism.

The formation of oxalate of lime calculus from mucus was first suggested by Meckel. It was he also who first considered *that all stones originally consist of calcium oxalate*, and that the formation of a precipitate was unnecessary for the production of calculi. The mucous membrane of the urinary passages becomes the seat of catarrh, " stone-forming catarrh." A tough mucus is secreted, which has a tendency to undergo acid fermentation, and oxalate of lime is a product of that fermentation. The oxalate of lime mucus is of a gelatinous character. It takes up more and more oxalate from the decomposing urine until it becomes somewhat stiff and firm, and finally stony. As long as the urine remains decidedly acid, the stones grow by accretion, and thus arises the nodulated surface, whence it obtains the name of the " mulberry calculus."

The Treatment of Oxaluria.—In the first place an attempt must be made to improve the general health by diet and hygienic measures to restore the general tone of the body, and especially the digestive and metabolic functions. In the majority of cases it will be necessary to *forbid* vegetarianism if that mode of feeding has been practised. It is essential that the food should be nutritious, and the amount of protein prescribed should average 100 grammes per diem, at least half the amount being derived from animal foods. An excess of animal food, and especially of carbohydrates, should be forbidden, and the food should be arranged on normal lines—*e.g.*, 100 grammes of protein, 100 grammes of fat, and 240 grammes of carbohydrate. Jellies and gelatin-containing substances should be forbidden, for the products of gelatin hydrolysis are glycocoll, creatin, and creatinin, all of which cause an increased excretion of oxalic acid. One would naturally cut down the consumption of all foods known to contain oxalic acid and oxalates—*e.g.*, spinach, rhubarb, tomatoes, beetroot, cabbage, celery, haricot beans, French

or snap beans; grapes, plums, currants, gooseberries, strawberries, raspberries, cranberries, apples, pears, and figs; sorrel, sheep-sorrel; pepper; tea, coffee, and cocoa (see table, p. 76). It is also advisable to leave out oranges, lemons, lime-fruit, and other fruit or fruit juices which contain citric acid. Toepfer[1] believes that oxaluria is not increased by the consumption of vegetables and fruit containing these acids, but that it is always due to defective metabolism of calcium or an excessive consumption of calcium salts in the food. Niemeyer believed that the use of beverages containing carbonic acid had quite a pronounced influence in causing oxaluria and the formation of oxalate of lime calculus. Drinking-water which contains an excess of lime tends to cause a deposit of calcium salts in the urinary passages.

The prescription of a vegetable diet, or one which is not rich in proteins, is common. Animal food increases acidity, and vegetable foods tend to alkalinity of the urine. Moore[2] says: "Such treatment often fails, and little wonder that it should fail if the two most important and abundant constituents of renal calculi are calcium oxalate and calcium phosphate, the solubility of both of which is enormously decreased by increasing the alkalinity of the urine. Calcium oxalate is the more common and abundant of the two; and is increased in amount by a vegetable diet. Again, while the patient is prohibited the purin-rich animal proteins, containing the progenitors of the obnoxious uric acid, no one suspects the harmless milk pudding or interdicts the ripe Stilton cheese, which becomes much beloved when other animal proteins are cut low. Yet these forms of milk proteins load up the body with calcium, which base is always present, whether the main bulk of the calculus be oxalate or phosphate or urate. The calcium salt of each of these acids is the most insoluble one which exists, and that is the reason why it is the invariable one present in calculi."

A different diet is necessary according to the type of patient who has oxaluria. A meat diet is necessary for the man who has spermatorrhœa, diabetes, etc.; but the gouty man, the man who does not metabolize proteins properly, should have his protein adapted to his capacity for dealing with it. In some cases it is necessary to restrict carbohydrates, and especially sugar and sweetened foods. Klemperer says we should prescribe those foods which contain a minimum of calcium and a maximum of magnesium salts. He allows any kind of meat or fish, excepting animal glands, but he excludes milk and eggs on account of the relatively great amount of lime in them. He allows any kind of fat, except the yolk of eggs. He prescribes apples and potatoes, and considers stale bread and rusks to be the best carbohydrates; but he also permits rice, barley, maize, dried peas, beans, and lentils. The patient should avoid sweetbread, liver and kidney, gravy made from spleen;

1 *Wien. Klin. Vortrage; cf. Brit. Med. Jour.*, 1904, ii., epitome 353.
2 *Brit. Med. Jour.*, 1911, i. 738.

jellies, fruit, and vegetables (except the pulses); tea, coffee, cocoa, and chocolate; rich cakes, pastry, and all rich and indigestible foods. The beverages allowable are water, weak tea or coffee, possibly a little stout or porter, and a small amount of whisky in certain cases. Klemperer considers whisky, weak coffee, or beer, and water neither increase nor diminish the excretion of oxalic acid; but alcohol tends to increase the defect of metabolism, which leads to the formation of oxalic acid, and to decrease the processes of oxidation.

In persons whose occupation is sedentary, and those whose natural disposition is against exercise, affairs are made worse by anything which tends to upset the processes of metabolism. These people, "instead of lessening the intake, often pile on more fuel, and so still further check the rate of the oxidative processes." These are the persons who are most benefited by a course of treatment at Contrexéville, Vittel, Carlsbad, Wildungen, Evian, and other places, where a course of alkaline waters is prescribed, and probably the most important result which follows is due to their influence on the general metabolism. Moore,[1] however, says: "The alkaline waters and alkaline medication at home are probably of little value. These forms of treatment are based on the solubilities of the supposed preponderating uric acid and urates, but the solubilities of calcium oxalate and calcium phosphate are exactly the reverse, and, if these solubilities give a true index, acid treatment is more indicated than alkaline." Johnston-Lavis[2] of Beaulieu says: "The thesis which Moore holds is that lime should be withheld from oxalurics. That is a consummation to be devoutly wished, but impossible of achievement No dietary can be planned which shall reduce the calcium so low as to be insufficient to combine with the few centigrammes of oxalic acid excreted daily, even by an advanced oxaluric. Surely, if this oxalic acid is neutralized by the lime salts of our food, any additional amount of lime cannot do further harm. But the problem is not to prevent the introduction of calcium salts, but the absorption of exogenous oxalic acid in the foodstuffs or the perverted metabolism of carbohydrates from which the endogenous oxalates are derived. Another problem is to prevent the accretion of calcic oxalates as a stone in the urinary passages. This cannot be done by calcium starvation. It has been tried and failed. . . . Two dominant factors are clearly demonstrable at Vittel, where we use a non-chloride calcareous water. . . . One is that large numbers of oxalurics resort to Vittel yearly, and the other that the diurnal amount of oxalates is markedly diminished, and frequently disappears. . . . The cure removes their stock of oxalates and improves their metabolism of carbohydrates so much that they form no more oxalic acid."

There is no doubt about the value of change of scenery or companions, pleasant surroundings, fresh air, freedom from worry or tranquillity of mind in improving the metabolism. Patients may be sent to Vittel, Evian, Contrexéville on the Continent; or to

[1] *Loc. cit.*

[2] *Brit. Med. Jour.*, 1911, i. 966.

Buxton, Malvern, or Leamington in England. The treatment may be assisted by cold bathing or douching, followed by friction of the surface, and proper exercise, especially walking, golf, quoits, tennis, etc.

Phosphaturia.—The amount of phosphoric acid normally leaving the body averages 3 grammes daily. Two classes of phosphates occur in normal urine—viz., *alkaline phosphates*, including sodium phosphate, which is abundant, and potassium phosphate, which is scanty; and *earthy phosphates*, of which calcium phosphate is abundant and magnesium phosphate scanty.

The composition of the phosphates in the urine is very liable to variation.

1. *Acid urine* contains the acid salts which give rise to the acid reaction; these are chiefly:
   (1) Sodium di-hydrogen phosphate, NaH_2PO_4.
   (2) Calcium di-hydrogen phosphate, $Ca(H_2PO_4)_2$.

2. *Neutral urine*, in addition to the foregoing, contains:
   (1) Di-sodium hydrogen phosphate, Na_2HPO_4.
   (2) Calcium hydrogen phosphate, $CaHPO_4$.
   (3) Magnesium hydrogen phosphate, $MgHPO_4$.

3. *Alkaline urine* contains, in addition to or instead of the foregoing:
   (1) Normal sodium phosphate, Na_3PO_4.
   (2) Normal calcium phosphate, $Ca_3(PO_4)_2$.
   (3) Normal magnesium phosphate, $Mg_3(PO_4)_2$.

Healthy and normal urine may contain a precipitate of the earthy phosphates of lime and magnesia, in starlike crystals or rosettes, if it is rendered alkaline by ammonia. Decomposing urine contains ammonia formed from urea; this renders the urine alkaline, and causes the precipitation of earthy phosphates. This urinary deposit has for the most part the appearance of a creamy-white precipitate, and it consists of triple phosphate ($NH_4.Mg.PO_4 + 6H_2O$) in the form of coffin-lid shaped crystals or irregular, six-sided plates.

The phosphoric acid in the urine chiefly originates from the proteins of the food and tissues, but also partly from the phosphorized constituents of the food—*e.g.*, nuclein, nucleo-proteins, phospho-proteins, lecithin, cholesterin, cerebrin, etc.

An excess of phosphates in the urine is due to various causes: (1) It arises from catarrh of the bladder, or cystitis, and especially from the fermentation which decomposes urea into ammonia. The ammonia combines with phosphate of magnesia, and forms ammonio-magnesium or triple phosphate. There are various bacteria which produce ammoniacal fermentation of the urine, and decompose mucus. The part played by mucus and other colloid substances in forming a calculus in the bladder is an important one. According to the theory promulgated long ago by Meckel, as long as the urine remains acid, only uric acid is deposited, and a stone may be formed with uric acid as a nucleus; but when catarrh arises, and is perhaps aggravated by the presence of a calculus, the urine becomes alkaline, and phosphates are thrown down, and cause the secondary formation of phosphates which surround such nuclei.

(2) An excess of phosphates in the urine may arise in consequence of persistent brain work (*nervous phosphaturia*), mental strain, worry, and diseases of the nervous system. (3) Persistent

phosphaturia, sometimes lasting for years, may occur in persons who habitually consume too much phosphorus in their food (*physiological phosphaturia*). The deposition of phosphates occurs because the urine is unable to keep them in solution, and it is favoured by a tendency to alkalinity of the urine. The phosphorus-containing food in excess is usually protein, and it is not necessarily animal protein. It may be the patient consumes too much vegetable food (which tend towards alkalinity of the urine), especially leguminous foods, such as lentils, peas or beans, wholemeal bread, brown bread, oatmeal, and other foods containing phosphates. Dyspeptic persons and others who follow sedentary occupations, and whose work is chiefly mental, are often vegetarians or consume a good deal of vegetables. The sulphur and phosphorus of all proteins become transformed into sulphuric and phosphoric acid during metabolism, and their combination with bases leads to the formation of sulphates and phosphates; hence phosphates arise from the metabolism of vegetable and animal proteins as well as from the inorganic phosphates of the food.

The presence of phosphorus in many of the important tissues of the body led to a discussion on the utility of the phosphates in wholemeal or brown bread, and the supplementary addition of inorganic phosphates to various foods. But the inutility of a large proportion of the inorganic phosphates normally present in foods was shown by the fact that insoluble earthy phosphates were excreted chiefly in the fæces, and the soluble phosphates were totally excreted in the urine. As a general rule, we take more phosphates in our food than we require to replace those lost by tissue metabolism.

The *Treatment* of phosphaturia is chiefly dietetic and hygienic. Fresh air, change of scenery, and freedom from work are important items. Cessation from excessive mental work or study is equally important. The sedentary man must find some occupation or "hobby" which will cause him to exercise his muscles. A man of means may ride, drive, hunt, shoot, and play golf; others must walk, play cricket, tennis, and so forth. The melancholy individual must find a cheerful occupation or one which will keep him from thinking too much about his own condition. In this connection it may be said that active work of a philanthropic nature usefully counteracts moroseness, despondency, and introspection. If the patient has practised vegetarianism, he must take a more rational diet, including 80 to 100 grammes of protein, half of which should be from the animal kingdom. If he has been in the habit of consuming too much animal food, his diet should be that recommended for the gouty. Both classes of patients should avoid legumes, brown bread, wholemeal bread, and oatmeal, and the dietary should consist chiefly of meat, eggs, milk, cheese, cereals, and milk puddings.

If vesical catarrh or pyelitis is a contributory factor, the treatment must be directed against that ailment; but the diet should be the same as for other forms of phosphaturia. It is easier to render the urine alkaline than to produce the opposite condition, for the

carbonates and vegetable salts of the food are excreted as alkaline carbonates. Benzoic acid, which is excreted as hippuric acid, is theoretically adapted for increasing the acidity of the urine and for the solution of phosphatic calculi; but its continued use is apt to upset the digestive organs. Tartaric and citric acids have a good effect in some cases. Therefore fruits containing benzoic acid, tartaric acid, and citric acid may form a part of the regular dietary in phosphaturia. These include lemons, limes, grape-fruit, oranges, gooseberries, strawberries, currants, cherries, grapes, plums, greengages, etc.

Cases of phosphatic albuminuria may be sent to St. Nectaire (France), whose waters are considered by Fiessinger to be sovereign in this complaint.

Pyuria.—There are various causes of pus in the urine—*e.g.*, calculus, catarrh of the urinary passages, pyelitis, especially bacillary pyelitis, abscesses, and ulceration of the mucous membrane.

Treatment.—Calculous pyelitis can only be cured by the removal of the stone. But pending an operation the patient should have a dietary for oxaluria or phosphaturia. In catarrhal or rheumatic pyelitis a few days' rest in bed, warm baths, warm alkaline drinks, barley-water, linseed tea, or slippery-elm-bark tea, and similar demulcent beverages are useful. In bacillary pyelitis alkaline-waters form the backbone of dietetic treatment; but an abundance of distilled water will have a good effect. Local applications, such as warm baths, mustard plasters, leeches, or dry cupping to the loins, are more or less soothing. The food must consist of milk, milk and barley-water or alkaline-water, milk pudding, jelly, eggs, a little fish, vegetables and cooked fruit, bread-and-butter, and tea.

When the pyuria is due to cystitis, the urine will probably be ammoniacal, and the alkaline treatment useless. Mucilaginous drinks are more suitable, but lime-water may be useful, from ½ to 2 pints daily being taken with milk.

When pyuria is recurrent, as, for instance, in pregnant women, the pyelonephrosis or pyelocystitis may be prevented by carefully dieting the patient. In such cases the food must be free from decomposable substances, such as high game or meat, old cheese, etc. The allowance of meat must be reduced to a small quantity at one meal a day. The food should consist of 3 or 4 pints of skim milk daily, one or two eggs, white meat or fish once a day, with green vegetables, porridge, macaroni, vermicelli, etc., *ad libitum*.

Albuminuria.

The following classification of albuminuria and its causes is by Fiessinger, in "Mémentos thérapeutiques des Practiciens":

1. *Tuberculous Albuminuria.*—(1) Primary bacillary nephritis, due to local tuberculosis, ending in caseo-ulceration of the kidney. (2) Secondary or tuberculin nephritis, caused by toxins elaborated in distant foci.

2. *Syphilitic Albuminuria.*—(1) Second stage, resembling acute nephritis; (2) third stage, the hepato-renal form, with hard and painful liver, possibly jaundice, and ascites.

3. *Exogenous Toxic Albuminuria.*—Due to the passage through the kidneys of metabolic or irritant poisons—lead, arsenic, mercury, phosphorus, cantharides, turpentine, and balsams.

4. *Endogenous Toxic Albuminuria.*—Due to disturbances of nutrition, (1) Arthritism, gout, diabetes, burns, and skin diseases. (2) Digestive and hepatic disturbances, cancerous cachexia, overwork or strain. (3) Infection starting from the mouth, alimentary canal, or biliary canals.

5. *Infectious Albuminuria.*—Influenza, scarlatina, diphtheria, typhoid fever, pneumonia, cholera, articular rheumatism, mumps, etc.

6. *Nervous Albuminuria.*—Neurasthenia, polyneuritis, epilepsy, hysteria, cerebral hæmorrhage, general paralysis, locomotor ataxy, Graves's disease, cyclical albuminuria, local application of turpentine to the skin, other forms of peripheral stimulation.

7. *Mechanical Albuminuria.*—(1) Venous stasis due to: (*a*) primary heart affections; (*b*) dilatation of the heart consequent upon pulmonary diseases and other causes of obstruction; (*c*) arteriocardiopathies, in which the kidneys are first involved, due to renal lesions, and not to renal stasis. (2) Orthostatic albuminuria. (3) Calculus, causing mechanical irritation.

Albuminuria, therefore, is due to a variety of causes, physiological and pathological. A minority of the cases are due to disease of the kidneys; and the majority to an altered state of the blood or failure in the vasomotor mechanism. The disturbances of the blood are due to indigestion and malnutrition in a person with idiosyncrasies; and the vasomotor disturbances are often associated with excesses in athletics, tobacco, venery, masturbation, oxaluria, exposure to wet and cold, etc. There is, for instance the **simple continuous albuminuria** in young adults who present no evidence of nephritis. There are no casts, but a continual slight albuminuria, not influenced by position. Then there is the **cyclical and orthostatic albuminuria** of early adult life, common in lads about puberty. The albuminuria only occurs or is much exaggerated on assuming the erect posture. Castaigne divides these cases into—(*a*) *Typical nephritis*, in which the albumin urea is aggravated by posture or walking; (*b*) *pyrexial albuminuria* of undoubted renal origin, aggravated by erect posture, common at the end of acute stage or in convalescence from nephritis; (*c*) *pyrexial albuminuria* from infectious diseases; (*d*) *albuminuria apparently functional*, but aggravated by erect posture, which on investigation turns out to be renal, sometimes called "residual albuminuria"; (*e*) *typical orthostatic albuminuria.* In the latter there is no renal inadequacy, and no evidence of previous nephritis; the albuminuria is not continuous; it only comes on after assuming the upright posture, and reaches a maximum in the middle of the day, when it may

form 20 per cent. of the urine, and declines in the evening. It is due to a disturbance of the vasomotor system, and the urine contains serum-albumin and serum-globulin. The blood-pressure falls from 120 or 125 millimetres to 90 or 95 millimetres of Hg on assuming the upright posture. This is the reverse of normal, and arises from arterial hypotonus in the splanchnic area; the blood accumulates in the visceral vessels, the kidneys become hyperæmic, and there is a transudation of blood-plasma through the glomerular vessels. These patients as a rule are nervous, have moist, clammy hands, a low-tension pulse, and other indications of vasomotor instability, such as headache, blushing, etc. In another group of cases the intermittent albuminuria is due to a rise of blood-pressure in the splanchnic area, which is maintained long enough to cause hyperæmia of the kidneys and transudation of albumin. Later in life the albuminuria may be due to general hypertonus arising from toxic causes; when the blood-pressure reaches 200 millimetres of Hg, the renal filter is forced, and albumin occurs in the urine. Intermittent albuminuria of a matutinal type sometimes occurs in the offspring of tuberculous persons. This is regarded by Fiessinger as a grave warning. The urine is copious, of high specific gravity at the same time the health fails and the patient loses weight; (*pretubercular albuminuria*); but when definite signs of pulmonary tuberculosis appear, the albuminuria disappears. When this form occurs in adults, it is often thought that the albuminuria is of a digestive origin, until a cough occurs and friction sounds are heard at the apex.

Alimentary Albuminuria.—This ailment occurs only in persons having an idiosyncrasy. The albumin appears after an excessive meal or prolonged muscular work, and never after fasting or periods of ordinary work. Ordinary food does not give rise to it, but an excess of some particular food—raw eggs, cheese, pastry, walnuts, etc. There is no such thing as physiological albuminuria; it is a pathological sign. Even when an excess of raw eggs causes albuminuria, the urine does not contain egg-albumin, but serum-albumin, which is small in amount and disappears with the resumption of ordinary diet. Grainger Stewart gave much attention to this subject. Leube studied it, and concluded that it only occurs in persons who are born with an abnormality of the renal structure and diminished resistance to the passage of albumin. It was also studied by Castaigne, who divided it into—(1) *Dyspeptic albuminuria*, the most frequent; (2) *albuminuria of a dyspeptic type* occurring in persons with chronic nephritis; and (3) *essential digestive albuminuria* occurring in healthy people. Castaigne finds all people with marked dyspepsia may have slight albuminuria, but it is especially noticeable in atony and dilatation of the stomach. The liver is large, the urine contains serum-albumin and globulin, often peptones, excess of urates and phosphates. There is no evidence of nephritis, but if the albuminuria lasts a long time, even though the stomach improves, chronic nephritis is slowly evolved.

Many people with chronic nephritis have no albuminuria under ordinary circumstances, but it occurs after an indiscretion in diet. It causes a doubtful prognosis. Essential digestive albuminuria occurs chiefly in healthy young men with no pathological disturbance, but an idiosyncrasy to some food. When heterologous albumin is introduced into the blood or subcutaneous tissues, the body gets rid of it at once by means of the kidneys. In normal digestion heterologous albumins are broken down and transformed to homologous albumin; but if the digestion of protein is disordered, some of the heterologous albumin is absorbed unchanged, and rapidly rejected by the body. The prognosis is usually good.

The Treatment of Albuminuria.—It is common for the physician to look on all cases of albuminuria, for which no cause can be found, as cases of obscure renal disease. This is an error. A youthful person might be converted into a chronic invalid by treating him as a case of Bright's disease. In **simple continuous albuminuria** the patient needs full nourishing diet, reasonable exercise, general hygiene, and tonic treatment. In **orthostatic albuminuria** greater care is necessary respecting running, jumping, football, and other violent exercises. All the patients suffer from vasomotor disturbances, and are the victims of more or less renal trouble, which call for special diet and hygiene. Lacto-vegetarian diet is better than others for them, but they may have two eggs daily, or a small helping of meat or fish at the midday meal. They should take very little wine, beer, salt, or coffee. They must *avoid* high game or meat, shellfish, spiced dishes, and indigestible foods. They should rub their skin with a rough towel once a day, wear flannel next the skin, and avoid catching cold. Youthful patients must have light, agreeable mental work and short lessons. There should be an inquiry into the habits (self-abuse, etc.). Castaigne recommends an annual visit to St. Nectaire, Evian, Vittel, Brides, or Vichy, according as nervousness, dyspepsia, gout, or obesity predominates. In **alimentary albuminuria** the treatment of atony of the stomach improves the condition, and the albumin usually disappears from the urine. In nephritic persons the albuminuria will be lessened by improving the digestion. Essential dyspeptic albuminuria should be treated like orthostatic albuminuria.

In **residual albuminuria** and those cases due to arterial hypertonus, arterio-sclerosis, mitral disease, venous engorgement, and arrested Bright's disease, the food should contain about 80 grammes of protein, about one-half being in animal foods. There need be no restriction of food so far as the kidneys are concerned, provided it is well and carefully cooked, tender, light, and easily digested. But it is necessary to consider the stomach and the arterial tension. If the patient has an idiosyncrasy to eggs or other foods, they must be avoided. If the albuminuria is associated with atony and dilatation of the stomach, gastro-intestinal fermentation, or enlargement and torpidity of the liver, the amount of meat and fish ought to be limited; white meats, such as fowl and rabbit, are preferable

for their easy digestibility. The amount of milk and vegetables should be increased. In these cases Castaigne finds it better to curtail the allowance of animal foods, avoiding underdone meat and raw eggs, and allowing lacto-vegetarian dietary (milk, legumes, fruit and nuts, etc.). When oxaluria and phosphaturia exist, treatment of these diseases will probably cure the albuminuria.

Albuminuria occurring in nervous diseases may necessitate a change in the régime. In Graves's disease it would not require any change from the ordinary treatment for that disease. But in general paralysis or locomotor ataxy an endeavour should be made to discover and remove the cause; it might be toxic, renal, or nervous. If it occurs in an epileptic patient, the treatment must depend on the time of its occurrence. Nothing can be done if it comes on just after a fit. But if it appears between the fits, the patient should be put on a salt-free diet of the lacto-vegetarian variety. If the arterial tension is very high or uræmia is threatening, a milk-and-water diet, aided by purgation and venesection, is the proper treatment. The same treatment is called for in albuminuria after cerebral hæmorrhage or injuries to the cranium, if the arterial tension is high; the fluids should not exceed 2 pints a day.

The albuminuria of neurasthenics may be central in origin—*e.g.*, phosphatic albuminuria—or due to gastro-intestinal and hepatic disorder, or a sequela of some infectious disease. When the albuminuria is clearly "residual," it would be better to treat the neurasthenia with generous diet without regard to the albumin, merely leaving out those articles detrimental to the kidneys. If, however, the albuminuria depends on renal inadequacy and high arterial tension, the neurasthenic will have hypertonus, headache, digestive and hepatic disturbances, which are better treated by a lacto-vegetarian and salt-free diet. In other neurasthenics, usually over fifty years of age, the albuminuria is independent of the kidneys, and, according to Fiessinger, due to a neuro-arthritic condition. These persons usually present hypotonus, although the coefficient of oxidized nitrogen in the urine is normal (*i.e.*, 85 per cent. is urea-nitrogen, and 15 per cent. other nitrogenous bodies). This form usually demands generous diet of the ordinary mixed kind; but if the low tension pulse is associated with gastro-intestinal and hepatic toxæmia, the food should be the same as for that condition.

Acute Bright's Disease.

A study of the products of metabolism eliminated during the course of acute nephritis led Von Noorden to conclude: (1) *The imperfectly eliminated bodies* are urea, creatinin, hippuric acid, phosphates, sulphates, potassium and sodium salts, colouring matter, and water. (2) *The matters tolerably well eliminated* are uric acid, xanthin bases, aromatic substances, amino-acids, ammonium salts, carbonates, chlorides, and sometimes water. The

imperfectly eliminated matters rapidly accumulate in the body; the retention of urea and salts, especially sodium chloride, is a factor contributory to the production of œdema. While it is important to relieve the system by promoting the action of the bowels and skin with purgatives, warm baths, wet-packs, hot-air baths, and diaphoretics, it is equally important that the solid cylinders of detritus and exudation matter should be removed from the renal tubules. To this end the patient may be encouraged to take large draughts of water, which have a diuretic effect by increasing the blood-pressure. The best drinks are gaseous alkaline waters, potash, soda, Apollinaris or Perrier waters; but Vals, Vichy, or Ems water, taken warm, has a good effect. The **imperial drink** is a valuable diuretic. Fruit juices taken in plain hot water are also useful (apple-water, black-currant tea, raspberry vinegar, and lemonade). The conversion of the organic acids into alkaline carbonates promotes diuresis, while they quench thirst and refresh the patient. Demulcent drinks—linseed tea, barley-water, oatmeal-water, etc.—were formerly considered soothing to the renal epithelium; but they are practically useless for that purpose, but should not be despised as beverages or diluents. As a general rule the patients may have such fluids unrestrained. But there is a small percentage of cases of acute nephritis in which the tubules are so completely blocked up that the kidneys cannot excrete it. In these cases the amount of liquid consumed should be limited, in a reasonable degree, not forgetting that warm liquids encourage diaphoresis, which is necessary to relieve the system of some of the toxins and water.

If vomiting is a marked feature of the illness, try some peptonized milk, and allow the patient to suck small pieces of ice, take iced lemonade, and Perrier or Apollinaris water. The mineral waters should not be spared in such a case, because the carbonic acid gas assists in checking the vomiting, and the increased blood-pressure arising from their ingestion may cause an increased transudation through the glomeruli and wash away the obstructing coagula. A mustard plaster over the epigastrium may also be useful in checking the vomiting.

The food should consist entirely of milk, whey, and buttermilk for a few days. There is no doubt that the excretion of nitrogen is seriously interfered with, and, whatever the desire of the patient may be, we must keep down the supply of nitrogenous food. Indeed, it is laid down by Hutinel that the treatment of acute nephritis with anasarca should always be started with a water-diet; and many authorities are in favour of *all* food being cut off for twenty-four to thirty-six hours, even when there is no anasarca, if the urine is suppressed, merely allowing alkaline-waters and demulcent drinks. There is no difficulty in doing this if the patient suffers from nausea and vomiting. But the majority of cases are not sufficiently severe to necessitate absolute abstention from food. As a general rule, even in the worst cases, whey and buttermilk

may be given if the patient is conscious, and usually about 1 pint of milk a day, well diluted, and in small doses. Whey and buttermilk, however, are specially suitable at this stage, especially when milk disagrees; they contain an amount of casein in an altered condition, besides lactalbumin, milk sugar, and lactic acid; they have a diuretic effect, and the nutriment in them can be increased somewhat by the addition of a tablespoonful of cream to each tumblerful.

Moreover, there are very many cases where whole milk may be given, especially where dropsy exists. In these patients the diminution in the excretion of urine is partly due to the dropsy, the kidneys not being so seriously impaired as in those cases where there is suppression of the urine, but no dropsy. Milk is the nitrogenous food least irritating to the kidneys. The amount given should in no case exceed 2 pints a day, but some cream may be added to increase the quantity of fat; and it ought to be diluted with one of the mineral or demulcent waters already named.

After twenty-four or forty-eight hours, if the vomiting is allayed, the patient may have some oatmeal gruel, a little bread-and-butter, and some sweetened tea. If the arterial tension is low, some strong coffee may be given; but if the tension is markedly high, both tea and coffee are contra-indicated. Alcohol is also contra-indicated. All meat juices, extracts, or essences, soups and broths are forbidden, because their nitrogenous extractives add to the mass of effete materials already waiting for the removal of the block in the kidneys. Neither should salt be added to the food, as it assists in retaining water in the tissues, and adds to the previously accumulated chlorides.

After a few days the diet may be improved by increasing the amount of bread-and-butter, and the addition of custard, junket, milk puddings, farinaceous foods, and stewed fruit. But no meat or fish should be allowed until the urine is free from albumin. As the symptoms subside, a little piece of steamed fish (sole, plaice, whiting, haddock, or turbot) may be given. When the last trace of albumin has disappeared, some poached or boiled eggs, and a little chicken, may be allowed with some mashed potato, cauliflower, vegetable marrow, or spinach. But as a general rule butchers' meat should not be permitted for two or three weeks from the commencement of the illness. By this time kidney beans, cabbage, lettuce, tomatoes, watercress, and fresh ripe fruit can be added to the diet. It is impossible to give a dietary which will be applicable to every case, but the following one would be suitable for the average case:

First and Second Days.—Milk, 20 to 30 ounces, diluted with much carbonated water (soda, potash, Perrier, or Apollinaris water), barley-water, rice-water, or lime-water; it should be taken in sips. Imperial drink, whey, buttermilk, toast-water, apple-water, fruit-juice and water. Ice to suck, lime-water and milk, or bicarbonate of potash in milk to check vomiting. The total liquid should be at least 4 pints.

Third Day.—Milk, 2 pints, well diluted. Custard, junket, cooked apple, cream. Oatmeal and milk with glucose. Savory and Moore's or Benger's food. Bread-and-butter, a cup of tea.

Fourth Day.—Milk, 2 to 3 pints; the other articles in greater quantity.

Fifth to Seventh Day.—Milk, 3 to 4 pints; milk pudding, custard, junket. Bread-and-butter, stewed fruit and cream.

Eighth Day.—Steamed fish, potato purée, vegetable marrow, boiled lettuce, spinach. Milk puddings, stewed fruit, etc.

Fourteenth Day.—Fish, potato, boiled vegetables. Tripe. Boiled or poached eggs. Other things as before.

Eighteenth Day.—Chicken and oysters may be added to the list.

Twenty-First Day.—Butcher's meat and full diet.

Von Noorden arranges the dietary for acute nephritis according to the severity of the disease. (1) In severe cases, in which the urine is suppressed or scanty, and there is danger of uræmia, he limits the food to ½ litre (17½ ounces) of milk daily. Ice is allowed, but he limits the intake of water to the smallest quantity, at the same time encouraging the removal of water from the tissues by diaphoresis. Such a dietary could not be continued more than four or five days, but by the end of that period the patient would either be dead from uræmia or his kidneys would show signs of returning activity, and more food and water could be allowed. (2) In less severe cases, with scanty urine, a moderate degree of œdema, but no present danger from uræmia, he prescribes 1½ litres (3½ pints) of milk and ½ litre (17½ ounces) of sweet cream. (3) In convalescence from acute nephritis he prescribes 2½ litres (4½ pints) of milk daily. This contains 80 grammes of protein. In addition he allows rice, bread, potatoes, peas and beans, and later on an egg or a small amount of meat, but in such quantities that the total quantity of protein does not exceed 100 grammes, and 25 grammes of urea should be excreted by the kidneys.

In 1905 Dufour[1] advocated a chloride-free diet for scarlatinal nephritis. He considered this renal complication of scarlatina to be serious, and the excess of chlorides throws additional work on the injured kidneys, whence arises the œdema, casts, and albuminuria so well known in scarlatinal nephritis. He holds that these symptoms are a contra-indication to the milk diet. He therefore prescribes a chloride-free diet, consisting of soup, eggs, cream, purée of vegetables, nuts, sweetbread, cream or other fat, and bread without salt. The drink should consist of Evian water and other alkaline diuretic fluids. The treatment aims at resting the kidneys, and under it he claims that all the symptoms speedily disappear.

Comby recommends the advisability of maintaining a milk diet for three weeks in scarlatinal nephritis, and a lacto-vegetarian diet for three weeks longer.

In the acute nephritis from infectious diseases, such as influenza, pneumonia, typhoid, scarlatina, diphtheria, etc., no difference from the dietary given above is necessary. Rest in bed, milk diet, and

[1] *L'Écho Méd. du Nord*, January 20, 1907.

plenty of water to wash out the débris from the renal tubules, is usually sufficient. Milk diet is especially essential for cases of nephritis with a tendency to uræmia, and salt-free diet for nephritis with œdema. The disease should not become chronic if it is adequately treated in the acute stage, and the milk and salt-free diet sufficiently prolonged. If a case becomes **subacute,** no meat or fish should be allowed, especially if the heart is failing or uræmia threatens. If the subacute stage is prolonged, a dietary similar to the following, which is prescribed by Fiessinger, should be given:

Breakfast and Tea. — Twelve ounces of milk and 2 ounces of saltless bread.

Midday.—Six ounces of meat without salt, ½ pound of vegetables cooked without salt, *or* the same amount of fresh fruit, 2½ ounces of saltless bread, and a tumblerful of water, or with 3 ounces of claret. The meat may be boiled with vegetables, which give flavour to it.

Dinner.—Milk soup, thickened with cornflour, etc., 2 ounces of bread, a couple of eggs, and water to drink.

On one or two days a week the diet should consist of milk alone. Too much liquid should not be allowed during the treatment, as it would increase the plethora, add to the burden of the heart, increase weight of the body, cause dyspnœa, and a sense of oppression. By keeping the consumption of liquids low, we may obtain a freer flow of urine. A small amount of salt may be allowed as the symptoms improve, but the urine should be examined frequently, and a constant lookout kept for œdema, increase of weight, oppression, and dyspnœa, which may necessitate the withdrawal of the salt and return to a milk diet.

Toxic Nephritis.—When nephritis occurs in a course of mercurial treatment, the remedy must be stopped, the patient ordered to rest in bed, and have a milk diet for eight days. Should there be no reduction of albuminuria at the end of that time, Siredey recommends, in syphilis, that specific treatment be resumed; but if the albuminuria becomes more marked under treatment, it must be discontinued again, and the milk and rest resumed. Nephritis occurring from phosphorus-poisoning should be treated by an emetic to remove any metal from the stomach, followed by a water or milk and water diet for a few days. When it is due to arsenic, the diet should consist of milk and water with calcined magnesia. When it is due to cantharides, the ordinary treatment of acute nephritis is required.

During pregnancy albuminuria may be due to some infectious diseases or toxæmia. The latter arises, according to Fiessinger, from failure of the liver—*hepato-toxæmia.* In both cases a milk diet is essential. Should œdema arise, it may be necessary to confine the patient to water diet for a few days, followed by milk and water diet, and finally pure milk diet. This method yields excellent results. The milk may be given raw, boiled, or baked, and cold or warm. It is often disliked, but toleration will soon be established, and the dose can be gradually increased. After about four days it is usually found that the urine increases and albumin diminishes; and the diet may be that for ordinary nephritis. If the albumin

does not diminish, the patient must be kept on milk, farinaceous foods, and fruit for the rest of the pregnancy. The urine should be examined once a week. Due attention must be paid to the bowels and skin, and symptoms of hæmorrhage or abortion must be looked for.

The treatment of **uræmia** in persons of all ages should be begun by a water-diet until the convulsive stage is passed and coma no longer threatens him. Water may be given in the ordinary way; but if the patient is unconscious, it should be injected at about blood heat into the colon through a long rubber tube, in doses of 1 pint every three hours. In bad cases the injection of cold water has a greater diuretic effect. At the same time diaphoresis should be promoted by warm blankets and hot-air baths.

When consciousness returns, the patient should be allowed plenty of water and its variants—oatmeal-water, barley-water, aerated waters, etc.—and about 1 pint of milk in divided doses. As improvement occurs, the milk may be increased, farinaceous foods added, and a dietary built up gradually, as in cases of acute nephritis.

Chronic Bright's Disease.

Numerous observations on the metabolism of nitrogen in renal diseases have been made. Baginsky found that the kidneys do not excrete nitrogen so well as in health, and it is chiefly excreted in the form of urea. Kornblum considered that there was no diminution in the excretion of nitrogen in chronic Bright's disease, but that *the metabolism of nitrogen was much retarded.* On the other hand, Mann found that in every case of chronic nephritis, sclerosis, and amyloid disease of the kidneys, the output of nitrogen was less than the income, and nitrogen was retained in the body. Von Noorden found that urea and creatinin are excreted with difficulty in parenchymatous nephritis, but the purin bodies—uric acid, xanthin, hypoxanthin, and guanin—and ammonia are well excreted. The conclusion to be drawn from these observations is that nitrogen equilibrium can only be maintained when a small amount of nitrogen is consumed; and if nitrogen is consumed above that limit, there may be a considerable retention of nitrogen, which is stored in the œdematous tissues, and tends to cause uræmia. If the nitrogen consumed is again lowered, the proportion of the outgo to the income increases until equilibrium is reached. The metabolism and excretion of nitrogen is therefore much retarded. Some examples of diets, with a comparison of the income and outgo of nitrogen, will illustrate this point (see table, p. 414).

The Diet in Bright's Disease.—These observations show that in most cases of renal disease nitrogen is retained in the body when more than 10 or 11 grammes—*i.e.*, 63 to 68 grains—of protein are consumed daily, and that the retention of nitrogen occurs even when the flow of urine is abundant. As a rule the more pronounced the

THE EXCRETION OF NITROGEN IN RENAL DISEASES.

The Kind of Disease and Diet.	Nitrogen: Grammes in— Food.	Urine.	Fæces.	Retained.
Chronic Parenchymatous Nephritis.				
1 Milk, 2,400 c.c.; bread, 726 grammes; tea	24·0	17·3	·9	+ 5·8
Milk, 1,000 c.c.; bread, 748 grammes; tea	12·5	7·5	2·3	+ ·7
Milk, 1,500 c.c.; bread, 743 grammes; tea	14·9	13·6	1·7	− ·4
2. Milk, 2,400 c.c.; bread, 340 grammes; tea	18·2	8·5	1·0	+ 8·7
	18·2	7·6	·7	+ 9·9
Milk, 2,400 c.c.; bread, 760 grammes; tea	26·8	15·6	1·2	+ 10·0
Milk, 1,826 c.c.; bread, 58 grammes	9·3	8·0	·3	+ 1·0
3. Milk, 1,757 c.c.; bread, bouillon	9·0	11·9	2·5	− 5·4
4. Bread, oatmeal, milk, and meat	14·8	10·7	7·8	− 3·8
5. Bread, meat, oatmeal, milk, and jam	17·8	10·4	5·7	+ 1·7
Chronic Interstitial Nephritis.				
1. Mixed diet	17·0	13·9	1·5	+ 1·6
2. Mixed diet	17·7	9·9	2·9	+ 4·9
3. Milk 250, meat 200, bread 120, grammes, five eggs	14·8	13·3	1·3	+ ·2
	9·9	8·9	·7	+ ·3
4. Soup, meat, eggs, bread, and vegetables	16·7	10·7	1·5	+ 4·5
	15·4	9·6	1·8	+ 4·0
	8·2	7·9	1·2	− ·9
5. Raw eggs (ten) and water	9·9	7·4	1·1	+ 1·4
	9·9	9·4	·8	− ·3
6. Meat 200, milk 250, bread 120, grammes	9·9	8·5	·9	+ ·5
	9·9	8·3	1·1	+ ·5
Sclerosis of the Kidneys.				
1. Milk 1,500, bread 100, grammes	10·7	6·7	·7	+ 3·3
Milk 1,500, bread 100, grammes, five eggs	16·7	10·1	·8	+ 5·8
2. Milk 2,310, bread 152, beef 80, grammes, butter and vegetables	20·9	10·1	2·1	+ 8·7
3. Milk 2,000, bread 304, grammes, six eggs	17·5	15·4	1·6	+ ·5
	17·5	10·8	1·4	+ 5·3
	17·5	12·6	1·5	+ 3·4
Amyloid Disease of the Kidneys.				
1. Milk 2,000, bread 290, grammes, seven eggs	20·1	10·8	2·1	+ 7·2
2. Milk 1,000, meat 150, bread 150, butter 43, grammes, three eggs, etc.	15·9	10·6	1·7	+ 3·6

dropsy the greater is the retention of nitrogen. The rules that we can draw from these observations are these:

1. *The diet must be sufficient in energy-producing value to maintain the body in a fair state of nutrition.* The total quantity of food allowed must depend on the amount of fat in the body. Obesity is a bad complication of Bright's disease. But there are many cases where the nutrition has already suffered. In such cases the food must be sufficient to improve the nutrition and increase strength. On the other hand, if the body is heavy and fat, we must endeavour to reduce it by slow degrees, and care must be taken when we reduce the weight that, at the same time, we do not reduce strength. The energy value of the food should therefore not be reduced below 2,000 to 2,200 calories. It is important that the weight of the body be watched, and a record kept of its variations. Changes in the quantity of water in the tissues naturally cause a variation in the weight. A sudden increase of weight is more likely to be due to dropsy than to an increase of tissues; and a sudden drop in weight is equally likely to be due to subsidence of the dropsy.

2. *The amount of nitrogen should be within the limits of the excretory power.* Nitrogen is assimilated fairly well, but its excretion is extremely slow; and the consumption of protein above the excretory limit leads to the retention of nitrogenous waste materials and increase of dropsy. The metabolism of protein and excretion of waste materials throws more work on the body than an isodynamic quantity of fat and carbohydrate. The average amount of nitrogen excreted through the kidneys daily by these people is somewhere about 10 or 11 grammes, and this would be derived from 66 to 76 grammes of digested, or 80 to 85 grammes of undigested, protein. It is therefore advisable to reduce the intake of protein to the lowest limit which is a safe allowance, and thus spare the kidneys and avoid the accumulation not only of nitrogenous waste products, but of the inorganic waste materials arising from protein foods.

3. *There is no difference in the effects of various kinds of protein on the nitrogen excretion.* It matters little, therefore, whether the source of protein be the animal or vegetable kingdom—meat, fowl, fish, milk, cereals, or legumes. (1) *As regards albuminuria*, the observations of Pettenkofer and Voit tend to show that in Bright's disease nitrogenous foods do not increase the albuminuria, and any increase is due to a personal factor. Herringham[1] says: "I have repeatedly estimated the daily amount of albumin excreted under various diets in order to show my students that a change from milk to fish, from fish to poultry or butchers' meat, does not increase albuminuria. . . . I do not believe there is any good reason for restricting the patient to fish or poultry, and still less to milk and vegetable proteins."

(2) *As regards the nitrogenous extractives*, it was formerly believed that the patient should only take white-fleshed foods—milk and

[1] *Brit. Med. Jour.*, 1910, ii. 1-5.

fish, or fish and poultry—and not red meat. This was due to a misunderstanding as regards the amount of extractives contained in these foods. Klemperer preferred his patients to have fish rather than meat, while Bouchard forbade fish on the ground that it contains toxins and increases the toxicity of the blood and urine. Pel said we must distinguish between the kinds of fish, but there is no need to exclude light and easily digested kinds. Red or dark meat was considered more harmful than the white flesh of chicken, pheasant, turkey, or rabbit. Game generally was condemned. But nobody explained why butchers' meat, venison, hare, partridge, quail, and other wild birds, are more harmful to the kidneys than fish or chicken, except that they belonged to dark-fleshed animals. Indeed, within the last few years it has been shown that the distinction between light and dark flesh, as far as the kidneys are concerned, is a myth. The difference was supposed to be due to a greater amount of extractives or meat bases in the dark-coloured varieties of flesh. But this assumption was incorrect. Von Noorden proved that the amount of extractives in red and white meat is about the same, the excess being in white flesh, but so small as to be negligible. From this circumstance he concluded that white flesh is no more suitable than dark flesh, but if one is allowed, the other may be allowed. The assimilation and excretion of food in chronic nephritis was studied by Von Noorden. He used a mixed diet in his experiments, including milk and eggs. The conclusions he drew from these observations were—(1) That the nutrients excreted in the fæces differs in no respect from those in health, and therefore the absorption and assimilation of food is normal; but the metabolism is not normal; (2) that the form in which proteins were consumed (meat, milk, eggs, or vegetables) had no influence on the action of the kidneys. Other observers have also shown that there is no fundamental reason for the distinction drawn between light and dark meat. Prior experimented with eggs, and found that cooked eggs did not increase the albuminuria, and raw eggs, when consumed in reasonable amount with other food, did not cause albuminuria in healthy subjects, nor increase it in albuminuric subjects. On the other hand, when raw eggs were consumed alone (say ten to fourteen eggs a day), they did cause albuminuria in healthy subjects, and they increased the albuminuria in nephritic subjects.

The influence of vegetable, animal, and mixed foods was studied by Zasiadko of St. Petersburg in ten patients suffering from chronic nephritis. Each patient was put on a vegetable diet for ten days, then on animal diet with some bread for ten days, and finally on mixed diet for ten days, and the following conclusions were drawn:

1. *Vegetarian Diet.*—The daily amount of albumin in the urine markedly decreased, the arterial tension sank, the pulse became slower, weaker, and more easily compressible; *but the dropsy increased considerably*, the general condition grew worse, the patient became weaker, apathetic, etc.

2. *Animal food*, with some bread: The daily quantity of albumin in the urine increased markedly, the arterial tension rose, the pulse became feebler and more frequent; but the daily amount of urine and the proportion of solids and specific gravity increased. *The dropsy diminished*, and the weight of the body decreased *pari passu* with the dropsy; the patient became stronger, more cheerful, and the general condition improved.

3. *Mixed diet* stood midway in its effects, but came nearer to animal food in its influence on the daily amount of albumin.

4. *Mixed diet is the best* for chronic Bright's disease, but in chronic parenchymatous nephritis, with profuse albuminuria, vegetable foods and milk should be in relative excess; while in interstitial nephritis, with general weakness, the animal food should preponderate over the vegetable food.

Offer and Rosingvist[1] recorded observations bearing out the conclusions of Von Noorden. Senator[2] maintained the opinion that dark meat is more injurious than light meat, and considered the view held by Offer and Rosingvist to be erroneous. He says they speak of extractive matters generally, but neglect to distinguish between nitrogenous and non-azotized extractives. Moreover, he says that no account was taken of the fact that meat is usually cooked before it is eaten, and that cooking alters the proportion. He quotes König, who states that as regards beef and veal the proportions are as follows:

Extractives in Beef and Veal (per Cent.): Raw beef, 0·46; roast beef, 0·72; boiled beef, 0·42; raw veal, 0·07; roast veal, 0·03. These figures led him to conclude that the paler sorts of flesh, and especially the flesh of young animals, is poorer in extractive matter, and that this conclusion has not been disproved. But Senator evidently overlooks the fact that there is more nucleo-protein in the flesh of young animals, and that this is split up into purin bodies during digestion (see Purin Bodies in Foods, p. 226).

It behoves us to spare the diseased organs all superfluous work, and keep from them those stimuli which are capable of damaging their structure. Von Noorden found: (1) *In ordinary cases* of Bright's disease the elimination is usually good, but it varies with regard to certain things, and these variations are unfavourable to the elimination of urea (if the food produces more than 30 grammes), uric acid, inorganic salts, water, lead, iron, arsenic, bromine, iodine, boron, and alkaloids. (2) *In acute exacerbations* and in the terminal stages of Bright's disease the same conditions obtain as in acute Bright's disease—viz., there is imperfect elimination of urea, creatinin, hippuric acid, phosphates, sulphates, colouring matters, and water, although the uric acid, xanthin bases, amino-acids, carbonates, and chlorides are not eliminated with greater difficulty than prior to the acute attack. It is therefore an important duty to keep from the patient all articles of diet containing metabolic products, which irritate the kidneys and are eliminated with diffi-

[1] *Berl. Klin. Woch.*, 1899, Nos. 33 and 34. [2] *Ibid.*, No. 45.

culty. For that purpose it is necessary to study the urine, to find out how the course of the disease is influenced by diet, to ascertain whether the kidneys are duly excreting the products of metabolism, and whether the food increases the tube-casts and albuminuria.

1. *To find out how much protein may be prescribed,* one should estimate the amount of nitrogen excreted by the patient when his condition is considered to be good. After many observations of cases of Bright's disease Von Noorden found that men of average weight excrete from 13 to 16 grammes, and women from 11 to 14 grammes of nitrogen daily. This output is equivalent to the metabolism of 92 to 112 grammes of protein by men, and 80 to 100 grammes by women. If the consumption of protein was increased so as to be equal to 15 grammes of nitrogen, the elimination became slow and irregular. It may therefore be considered a settled point that 95 grammes of protein should be the upper limit of consumption by a person with chronic Bright's disease, even when his kidneys are well compensated, the general condition good, and the strength maintained. But the upper limit cannot be reached by everybody, and it would be useless to try and force the kidneys to eliminate more waste nitrogenous materials than they possibly can do. Therefore is it strongly recommended that the nitrogen elimination be closely watched. The twenty-four hours urine should be collected, the total nitrogen, urea, and percentage of albumin ascertained and recorded, together with the patient's weight. The patient should then be placed upon an experimental diet for three days, after which the total nitrogen, urea, albumin, and weight should be again recorded. The diet is then adjusted to the excretion, and after another space of three days the observations are again made and recorded, until a dietary is arrived at which agrees with the patient, and the nitrogen in the food and excretions balance. If an acute exacerbation occurs, the amount of protein in the food should be temporarily reduced. But in the ordinary course of the case the protein allowance should be moderate, neither too low nor too high. The upper limit has been fixed at 95 grammes of protein daily, and we should also have a lower limit. The lowest physiological limit for the average individual has been discussed in the chapter on the Normal Protein Requirement. Those remarks need not be repeated. But I do not think it is advisable to reduce the allowance of protein below 63 grammes daily in any case, and this amount should give rise to the excretion of 10 grammes of nitrogen.

2. *To find out the kind of protein* which should be allowed observations must be made of the effects of various foods on the albuminuria and the excretion of uric acid and purin bases. It is recognized that the same diet will not suit every case. Some articles increase or decrease the albuminuria. As a general rule, milk for a short time causes an increase, but later on a decrease, of the albumin in the urine. An exclusive milk diet diminishes albuminuria less than a vegetarian diet, and a meat diet increases it as a rule, although

it may lead to a reduction of the albuminuria in some cases. On the whole, a mixed diet gives the most satisfactory result. But it is better to test the patient with the various articles individually. Robin,[1] at the International Medical Congress, 1900, described his method of discovering the diet most suitable for the patient. Firstly, he begins by giving a milk diet only, the result being an immediate increase of albuminuria, which gradually diminishes and becomes stationary. Secondly, at this stage vegetables are added to the diet. A new oscillation in the albuminuria is caused thereby, but it soon settles down, and usually results in the albuminuria being still further reduced. Thirdly, meat is cautiously added. In this way he found it is possible to determine whether milk alone, milk and vegetables, or meat, milk, and vegetables, caused the greatest reduction in albuminuria. Each food can be tested as regards its effects on the albumin, and those which are deleterious can be eliminated from the diet. It was by this method that Robin arrived at the conclusion that bread never increases albuminuria; wine causes a slight increase; beef and veal are to be recommended more than mutton or fowl, and fish should be forbidden. The effect of red and white meat has already been discussed, and it has been shown that the ancient dogma about red meat containing more extractives than white meat is erroneous; on the other hand, fowl and rabbit sometimes contain more extractives than beef, but the difference is so trifling that it is absolutely of no consequence whether the patient eats red or white meat, and, putting aside the patient's peculiarities, which Robin suggests should be discovered by the above means, it does not matter whether the albumin is derived from meat, fish, eggs, milk, and vegetables.

The diseased kidneys do not always eliminate uric acid and other purin bodies well, especially when the quantity consumed is large; but Von Noorden found, as a general rule, the kidneys are able to eliminate quantities of uric acid up to 0·75 gramme (10 or 12 grains). This quantity is readily and steadily eliminated daily by nephritics, and this is the amount normally excreted by a man on an ordinary diet. But the uric acid would be easily increased in amount if we allowed the patient to consume sweetbreads, brains, liver, kidneys, and other glandular organs rich in nuclein and nucleo-proteins. If these foods are forbidden, and the amount of protein from meat, fish, eggs, milk, etc., does not exceed the limit named above, the quantity of uric acid to be eliminated will not exceed 0·75 gramme daily.

3. *How much fluid should be allowed?* This depends on the amount of urine excreted, the existence and extent of œdema, and the condition of the organs of circulation. In acute nephritis we have to do with kidneys which are blocked up and unable to excrete water; there is not merely a retention of water in the tissues, but also of the waste products of metabolism. In chronic parenchymatous nephritis, and granular kidney without dropsy, the kidney

[1] *Brit. Med. Jour.*, 1900, ii., epitome 157.

is able to excrete water. Therefore the consumption of water must be looked upon as having a diuretic and antiuræmic effect. For this reason it was formerly taught that the patient should drink a large quantity of fluids, the intake being governed by the output. There is some danger, however, of the patient taking an excess of fluids, and if the water is not excreted, it simply increases the œdema and the hydræmia. The position with regard to the consumption of fluids has changed somewhat, because we know that there are other problems to face than that of ridding the system of effete materials, desirable as this result may be. Every patient with chronic Bright's disease is suffering from changes in the heart and vessels. In many cases the heart trouble is more dangerous than the kidney disease. If in these cases we overload the system with water, a heart which is compensated may become dilated and feeble. So long as the nutrition is good, the increased blood-pressure due to the disease is met by compensatory hypertrophy. But a continued strain, arising from an overloaded circulation, may precipitate the failure of compensation, associated with attacks of cardiac pain, irregularity of the pulse or arrhythmia, and cardiac dropsy. Consequently the effects of the consumption of liquids must be watched.

In cases of failure of the cardiac compensation Von Noorden recommends the rule of Oertel for heart cases should be followed —viz., never to allow the patient to take more than 1½ litres (52 ounces) of fluids daily. Assuming that the solid and semisolid foods taken during the day contain 17 to 25 ounces of water, the amount of urine under this régime should be 46 to 52 ounces a day.

The influence of this restriction of fluid must be watched. It may be the means of producing a betterment of the general condition. But this does not always follow. It may cause a diminution in the urinary excretion. If the amount of urine sinks, the percentage of albumin will probably be slightly increased. Von Noorden does not shrink from curtailing the intake of fluid; he believes the advantages derived thereby are greater than the disadvantages. If, however, it is found that the curtailment of liquids has an adverse influence on the excretion of urea, uric acid, and salts, the reduction of liquids must be discontinued at once, in spite of the beneficial effect of restriction on the heart, circulation, and dropsy. The retention of poisonous waste products is fraught with dangers which must be avoided. In such cases Von Noorden recommends the amount of fluids "be alternately increased and reduced. The consumption of liquids should never be less than 1¼ litres (2 pints) daily, and once a week the system should be flushed by giving 2½ to 3 litres (4 to 5 pints), adding for gouty cases small doses of sodium bicarbonate."

A consideration of the foregoing shows that, while we cannot restore health to parts of the kidneys which have become diseased, we can do a good deal to prevent them getting worse, to prevent other portions from getting affected in the same way, to improve

symptoms that already result from the disease, and establish compensation. Our efforts at treatment will always be handicapped by our ignorance of the cause, but if the cause is recognizable and can be removed—*e.g.*, alcoholism or plumbism—we may do more for the patient than when the cause is irremovable. But unfortunately our guesses at the cause are often beside the mark or shots at random. The disease may be due to some indiscoverable chronic infection or disturbance of metabolism. We are therefore not able in many cases to work from the point of view of the cause, and are driven to general principles. "Such people," says Herringham, "are like a town in which part of the drainage system has been put out of order. They are unable to cope with the same amount of solid and liquid excreta as before. Therefore they must be regarded as permanently on a lower plane. They can no longer overeat and overdrink themselves as other people do. They must spare their kidneys." The quantity of food and drink considered advisable has been fully discussed above. The patient must take less than the average individual. Without arguing that half rations are better for healthy people than the usual amount, we know that people can live and maintain their nitrogen balance in equilibrium on about half the amount of proteins prescribed by physiologists, health and weight being maintained. We know that individuals who do no active muscular work require only about half as much energy as those who do laborious work, and therefore the calorie value of the food should be little more than 2,000 calories a day. It should be again observed that any change from milk to fish, or fish to meat, and even a change in the opposite direction, will probably be followed by a temporary disturbance of the albuminuria, and an increase in the amount of albumin for a day or two. But it quickly falls again, there being no permanent increase with the change from one form of protein to the other. Of course, no estimations of albumin are of any value unless made from the twenty-four hours' total urine. The dietary may be divided into that for cases without dropsy and those with dropsy.

1. **Dietary for Cases without Dropsy.**—The diet should be light, nourishing, easily digested, unirritating, but not free from cellulose. It should contain from 60 to 75 grammes of protein, and yield 2,000 to 2,500 calories according to the occupation followed by the patient.

As a general rule the patient may have meat, fowl, or fish, *once a day*, usually in the middle of the day, and the amount should not exceed 3 or 4 ounces. An egg, or egg and bacon, or a fillet of plaice, may be taken at breakfast-time. It is advisable that one-half the protein should be derived from animal foods, and therefore it will be necessary to add some milk to the diet. One pint of whole milk and 3 ounces of cooked meat will contain about 40 grammes of protein, and that should be the limit of animal food. If 4 ounces of meat, fish, or fowl be taken, the milk should not exceed $\frac{2}{3}$ pint. If there is any evidence of considerable irritation in the kidneys, the

allowance of meat, fish, or fowl, must be reduced to 2, or even 1½, ounces daily, the milk being correspondingly increased. In some cases it may be necessary to allow solid animal food only two or three times a week, milk being given to replace it. But it must never be forgotten that the protein, whatever its source, has to be converted into urea, and there is no evidence that urea from one source is excreted more easily than from another.

The following diets would contain from 64 to 78 grammes of protein and 2,000 to 2,200 calories, of which about 92 per cent. would be digested:

1. Cooked fish, 3 ounces; bread, 6 ounces; butter, 1 ounce; tea; sugar, 1 ounce; cream, 2 ounces; marmalade; beef, cooked and free from bone, 3 ounces; cooked potatoes, 3½ ounces; cooked green peas, 2 ounces; rice pudding, 3 ounces; bananas, 3½ ounces. Total protein, 78 grammes; energy, 2,020 calories.

2. Oatmeal, 1 ounce; milk, ½ pint; bread, 6 ounces; butter, 1 ounce; one egg; tea; sugar, 1 ounce; cooked fowl, 2 ounces; potato, 3½ ounces; cauliflower, 3½ ounces; tomato; tapioca pudding, 2 ounces; apples, 3½ ounces; cream, 2 ounces. Total protein, 76 grammes; energy, 2,035 calories.

3. Fat smoked bacon, 1 ounce; one egg; bread, 6 ounces; butter, 1½ ounces; tea; sugar, 1 ounce; cream, 1 ounce; tripe, 4 ounces; boiled onions, 3½ ounces; potato, 3½ ounces; custard (containing one egg, 6 ounces of milk, ½ ounce of sugar); stewed prunes, 2 ounces; watercress, lettuce, or other salad. Total protein, 66 grammes; energy, 2,100 calories.

4. Oatmeal, 1 ounce; milk, ½ pint; bread, 4 ounces; butter, 1 ounce; tea or coffee; cream, 1 ounce; marmalade or jam; lettuce, watercress, etc.; mutton, 3 ounces of leg or shoulder free from bone; potato, 3½ ounces; kidney or string beans, 3½ ounces; tapioca pudding, 2 ounces; sugar, 1½ ounces; fresh fruit—apples, pears, etc., 16 ounces. Total protein, 64 grammes; energy, 2,000 calories.

The alimentary organs must be duly considered. All those dietetic articles detailed "to be avoided" in the treatment of indigestion or chronic gastric catarrh and liver complaints, should be avoided in chronic nephritis. If, under the influence of the dietary chosen, it is found that the urinary solids are of a proper character and composition, the density of the urine is satisfactory, the albumin diminishes, and the general condition of the patient improves, we may conclude that the diet agrees with the patient. If, on the other hand, the general condition is not maintained, but the arterial tension increases, and the density of the urine is not satisfactory, even though the amount of urine remains the same, it is probable that there is some error in the diet which must be rectified. There can be no greater error than to allow strong broths, soups, meat extracts, meat essences, meat juices, or meat powders, which are rich in creatin, or substances like sweetbread, spleen, liver, kidney, brain, oysters, mussels, crab, of lobster, because these are particularly rich in nuclein bodies and other nitrogenous

products, which speedily become transformed into urea, uric acid, or other purin bodies, which have to be excreted. Not only are such foods dangerous on account of the defective elimination of waste materials, but to such people they are positively poisonous, and tend to aggravate the disease. The kidneys are irritated thereby, and the accumulated materials intensify the risk of uræmia. It is also possible that animal food of any kind does not agree with the patient, and a vegetarian diet is necessary.

Vegetarian Diet in Bright's Disease.—Observations have previously been made on the effects of vegetarian food, animal food, and mixed diet on the albuminuria and general condition. This matter need not have been referred to again except for the reason that a vegetarian diet has for some years been prescribed by various people as a treatment for the disease. Vaughan[1] of Michigan University believes that Bright's disease is due to a toxicity of the blood-serum exerting a specific action on the secretory cells of the kidneys, and the object of his treatment is to profoundly alter the proteins of the blood, and through it act beneficially on the kidneys. He forbids all animal food. The diet prescribed by him consists of bread, cereals, legumes, potatoes, green vegetables, fresh fruit, sugar, and zwiebach—a kind of "pulled bread"—cream, butter and cheese.

The following is a sample dietary prescribed by him:

	Protein.	Fat.	Carbohydrate.
	Grammes.	Grammes.	Grammes.
500 grammes (1 pint) of cream ..	5	150	27·60
200 ,, cornmeal	20	8	130·60
100 ,, zwiebach	14	24	60·00
50 ,, butter	—	40	—
20 ,, sugar	—	20	—
Total (calories, 3,134) ..	39	222	238·20

Vaughan takes no account of the fresh fruit and vegetables consumed by the patient, and apparently allows them *ad libitum*. He claims that after a few weeks of such diet the patient loses his desire for meat and egs; a hard-working man can live upon it with ease, and the albuminuria diminishes. The reduction of albumin in the urine corresponds with that found by other authorities; but it should be observed that while the diet causes a decrease of albumin and arterial tension, there may be an increase of œdema. There is no more difficulty about such people living on a vegetarian diet than normal individuals. But it is questionable whether it is possible, as Vaughan claims, "to profoundly alter the proteins of the blood." According to modern theories, all the proteins of

[1] *North-Western Medicine*, September, 1903.

our food are broken down into amino-acids in the alimentary canal, and the proteins of the blood (which are always of the same kind and composition) are reconstructed out of such amino-acids. Vaughan's argument therefore falls to the ground. The chief value of vegetarian food is that it is a low protein diet, containing less extractives and purin bases than ordinary mixed diet. Unfortunately the dietary by Vaughan takes no account of the fruit and vegetables consumed, and the record of the total protein is not exact. The amount stated (only 39 grammes of protein) is perilously low, and it is very probable that a patient would not long remain "fit" and able to perform his daily task on such a low protein diet. We have previously fixed the amount of protein for a renal patient as something between 65 and 76 grammes daily. Considering that vegetables are not so well and easily digested as animal foods, the intake ought not to be less than 76 grammes of protein when it is wholly derived from the vegetable kingdom. If the physician desires to try a vegetarian diet, the following examples may be useful:

1. Bread, 12 ounces; butter, 1½ ounces; dried beans, 3½ ounces; white sauce, 2 ounces; potatoes (cooked), 3½ ounces; cream, 2 ounces; rice pudding, 2 ounces; sugar, 1½ ounces; tea. Total protein, 82 grammes; energy, 2,714 calories.

2. Bread, 8 ounces; butter, 1½ ounces; tea; sugar, 2 ounces; dried peas, 3½ ounces; white sauce, 2 ounces; oatmeal, 2 ounces; cream, 5 ounces; apples; pears; grapes. Total protein, 80 grammes; energy, 2,345 calories.

3. Bread, 6 ounces; butter, 1 ounce; sugar, 1½ ounces; lentils, 2 ounces (for vegetable soup); potatoes (cooked), 3½ ounces; cauliflower (cooked), 3½ ounces; roasted peanuts, 4 ounces; raw apples, 7 ounces. Total protein, 76 grammes; energy, 1,988 calories.

3. Almonds, 2 ounces; dried raisins, 2 ounces; bananas, 7 ounces; bread, 12 ounces; butter, 1½ ounces; cream (for tea), 1 ounce; tapioca pudding, 2 ounces; milk, ½ pint. Total protein, 80 grammes; energy, 2,700 calories.

5. Oatmeal, 1 ounce; milk, 5 ounces; bread, 6 ounces; butter, 2 ounces; sugar, 1 ounce; cream, 1 ounce; tomatoes, 4 ounces; grapes, 1 pound; Brazil nuts, 4 ounces. Total protein, 86 grammes; energy, 3,074 calories.

6. Oranges, 1½ pounds; filbert nuts, 2 ounces; dates, 4 ounces; dried Navy beans, 3½ ounces; white sauce, 2 ounces; tomatoes, 2 ounces; bread, 6 ounces; butter, 1½ ounces; cream, 1 ounce; milk, ½ pint. Total protein, 76 grammes; energy, 2,630 calories.

Beverages.—The total amount of fluid to be allowed has already been discussed. It remains to consider what kinds of liquids may be taken. Pure water is always permissible up to the limit of liquids allowable. But very few people are satisfied with pure water; they want it flavoured. The waters containing carbonic acid gas and weak alkaline or saline waters are recommended, especially

those of Apollinaris, Perrier, Vals, Vichy, Ems, Kissengen, Wiesbaden, Bilin, Carlsbad, Saratoga-Vichy, Hot Springs (Arkansas), Harrogate, Leamington, Tunbridge Wells, Malvern, Contrexéville Homburg, and Wildungen.

Tea, coffee, cocoa, kola, guarana, and other substances of a like character can be taken in strict moderation; the quantity must be limited, because these substances contain a relatively large amount of purins. Coffee contains 0·2 gramme per cent. of purins, and causes an excretion of 0·075 gramme of purins. Some interesting experiments showing the effects on the kidneys of the continued use of caffein were carried out by Tomasetti.[1] The animals used were rabbits. A dose of 1 centigramme of caffein per kilo of body-weight was administered for thirty or forty days, and it caused changes in the cells of the convoluted tubules of the kidneys. A daily dose of as little as ½ centigramme of caffein for sixty days caused changes in the cells of the tubules, and produced distinct vascular and interstitial alterations. Caffein increases the blood-pressure, and is cumulative in its effects. Zenetz[2] found that when patients were given 20 to 30 centigrammes (3 to 4½ grains) of caffein two or three times a day, it produced a rise in blood-pressure and some increase of urine, but did not markedly decrease the œdema. If this amount of caffein were consumed for four or six days, the patient experienced a sensation of constriction in the chest, dyspnœa and insomnia, as a result of increased blood-pressure. The toxic dose varies in different individuals. Caffein continues to be excreted in the urine for ten to fifteen days after the last dose, which proves not only that it accumulates in the body, but it is excreted very slowly, and should not be given in arterio-sclerosis, cardiac and renal diseases. One ounce of tea or coffee contains ½ gramme of caffein; therefore tea is better than coffee because less is used. Cocoa is less injurious than either; its active principle, **theobromin,** being frequently prescribed as a remedy in Bright's disease, especially in granular contracted kidney.

Alcohol is better withheld. and can only be allowed in very small amounts. It is nearly always injurious by increasing arterial tension and quickening the heart. When small quantities are consumed, all but 5 per cent. is fully oxidized in the body. But an excessive consumption of alcohol may have been the primary cause of the renal disease by its local influence. In such a case the patient must have habitually consumed more than 2 ounces of alcohol daily. People accustomed to take much alcohol will not as a rule consent to total abstinence, and therefore we must do our best to keep the consumption down to 2 ounces, which is equal to 4 ounces of good whisky or Holland gin, or ½ pint of light wine. Spirits should be well diluted. But there is another class of patients who have probably never been "drinkers." Some of these might be benefited by a wineglassful of good generous wine or ½ ounce of

[1] *Cf. Brit. Med. Jour.*, 1911, i., epitome 116.
[2] *Wien. Klin. Woch.*, December 9, 1899.

pure malt whisky twice a day. Hale White[1] says: "If the heart is feeble and the arterial tension is low, a small quantity of alcohol may do good, as it also may if the digestion is weak or the patient cannot sleep." A moderate amount of good claret or Burgundy will assist in restoring the cardiac energy and improving nutrition, which are objects requiring considerable attention in the dietetic treatment. Warrington[2] also says: "Alcohol is to be forbidden in general. But its transitory use is indicated when there is a lack of appetite and disturbance of the heart. A small amount of champagne in the evening may prevent the nightly attacks of uræmia and cardiac asthma; but it should be forbidden as a table beverage; it threatens the heart and the walls of the bloodvessels."

Tobacco ought to be taboo; there is no doubt that it increases the arterial tension, and is injurious in all renal diseases.

2. **The Dietary in Cases of Dropsy.**—The diets which have been prescribed for renal disease with dropsy are milk diet, partial milk diet, mixed diet, dry diet, and salt-free diet. The special objects of treatment are to unload the lymphatics, to establish a circulation from the bloodvessels to the lymphatics, and quicken the lymphatic circulation by position, passive movements, and massage.

Milk Diet.—This diet would cause an abundant flow of urine, even when there is a tendency to suppression. When strictly carried out, it includes the consumption of 3½ to 5¼ pints of milk. The lower limit is fixed by the expenditure of the body during absolute rest in bed—viz., 1,400 calories. The upper limit (5¼ pints) would yield 2,050 calories and contain 110 to 115 grammes of protein, and is fixed by the amount of liquid which the body is capable of dealing with. In many cases the kidneys cannot excrete 5¼ pints of urine daily, and the upper limit must then be fixed by the ability of the kidneys to deal with it, due allowance being made for excretion by the skin and lungs. The advantages of milk diet in dropsy are—(1) Its freedom from purins and other substances calculated to irritate the kidneys; (2) the digestibility of its albumin; (3) the diuretic action of the lactose; (4) the amelioration of the general symptoms which follows its use; and (5) the loss of albumin is made up by milk. It is not necessary that the milk should be taken plain; it may be flavoured with celery salt, or boiled with the green tops of celery, made into soup with vegetables, milk-tea, cocoa made with milk, milk jelly made with isinglass, junket, sour milk, koumiss, kephir, etc.

The disadvantages of exclusive milk diet are—(1) Too much albumin; (2) too much water; (3) too much phosphoric acid; and (4) too little iron. The amount of protein in 5¼ pints of milk is above the limit considered advisable for renal patients; it would yield 38 grammes of urea, which is more than the average excreted by a man doing ordinary work. If the protein is not excreted, it is retained in the body in the form of floating protein or urea.

[1] *Brit. Med. Jour.*, 1904, ii. 886-890. [2] *Practitioner*, 1909, p. 162.

The deficiency in iron could be made good by medicines. The amount of phosphoric acid in 3 litres of milk varies from 3 to 4 grammes; this is considered to be excessive and injurious in chronic renal diseases. Von Noorden eliminates the phosphoric acid by adding lime-water to the milk. In this way it is converted into an insoluble phosphate of lime, which is excreted by the bowels; but the addition of lime-water increases the quantity of liquid and increases the disadvantage.

The *indications for milk diet in* chronic renal disease are an acute exacerbation or subacute attack of nephritis, the existence of œdema, uræmia, or symptoms, pointing to renal or cardiac inadequacy. The absence of œdema *contra-indicates* the use of milk diet; neither should it be prescribed in compensated renal sclerosis, amyloid kidney, tubercular nephritis, residual, orthostatic, or cyclical albuminuria.

There can be no doubt as to the diuretic effect of milk, koumiss, or kephir. During treatment by milk diet the majority of patients lose weight, the output of nitrogen is increased, the uric acid decreased. The increased excretion of nitrogen is not due to cleavage of tissue proteins, but removal of retained waste products, for nitrogenous equilibrium is maintained when only 3½ pints of milk is consumed during rest in bed. In nearly all cases the dropsy diminishes. The loss of weight is partly due to elimination of water, and partly to the consumption of fat; it is most striking at the beginning of treatment. The outgo of nitrogen exceeds the income at first, but equilibrium is reached in four or five days. As the treatment proceeds, the excretion of water and loss of weight become less marked, and there may be a slight gain. In a small percentage of cases the excretion of urine does not equal the milk consumed. It is obvious that in such a case the dropsy will not be relieved; it will tend to be exaggerated. The hydræmic plethora and weight will be increased. There are other cases where the upper limit of the milk diet cannot be reached, because the consumption of such a large amount of fluid increases the blood-pressure, throws extra work on the heart, and unduly irritates the kidneys. The diet should then be abandoned, for the excess of fluid tends to apoplexy and other forms of hæmorrhage.

Modified Milk Diet.—In the majority of cases it is not necessary to continue an absolute milk diet for more than fourteen days, some modification then being required; other patients cannot tolerate it because of idiosyncrasy, nausea, or anorexia. Intolerance may be met by altering the flavour of the milk by tea, cocoa, or extract of coffee (which consists largely of chicory), cereal coffee (which is free from caffein), or extract of malt. If intolerance becomes very marked, some other food must be combined with it; the most suitable are rice, sago, tapioca, cornflour, and arrowroot, made into puddings, blanc-mange, or custard. Thus 3½ pints of milk, 1½ ounces of sugar, and 4 ounces of rice or sago, for puddings, and ½ pound of grapes, would provide 85 grammes of protein and

1,970 calories. The grapes, or an equivalent amount of dried raisins, would assist by preventing constipation.

When the lower limit for milk diet only is tolerated, it soon becomes necessary to supplement it by the addition of fat and carbohydrate. We cannot then do better than add farinaceous foods—oatmeal, milk puddings, bread-and-butter. There is probably no farinaceous food more suitable for these cases than oatmeal. The following would be a sufficient dietary: 3½ pints of milk, 2 ounces of oatmeal, 2 ounces of bread, ½ ounce of butter, and 1 ounce of sugar. It contains 84 grammes of protein, 124 grammes of fat, 168 grammes of carbohydrate, and has a *gross* value of 2,194 calories, and net value of 1,843 calories derivable from digestible and assimilable material. The milk may be consumed plain, as oatmeal and milk, oatmeal pudding, milk-tea, cereal coffee, sour milk, koumiss, or kephir. Bread, butter, and tea make a useful variation, and can be taken with a little stewed fruit (prunes, figs, or apples), or fruit salad. Now and then a further variation may be made by substituting rice, sago, or tapioca pudding for oatmeal; but, as a general rule, oatmeal should be taken twice a day in the form of gruel, porridge, or pudding.

Kephir and koumiss have a distinctly diuretic action, due to lactose. Under the influence of these foods the urine increases day by day, the albumin diminishes, and in many cases disappears after two or three weeks. The small amount of alcohol appears to have no deleterious effect. The advantages of the **sour-milk** treatment are derived partly from the action of lactic acid in preventing the putrefactive processes in the alimentary canal and removing one of the causes of hypertension. This treatment is worthy of a prolonged trial in cases of granular kidney and other renal diseases marked by arterial hypertension and cardiac hypertrophy. It promotes a free secretion of urine, diminution of the albumin, a lower nitrogen output, as well as decreased arterial tension and an improvement in the general nutrition.

Mixed Diet.—When the patient has been for some time on an exclusive or modified milk diet, it will be necessary to return to the mixed diet. The precise moment when this return should be made will depend on the patient's condition. An exclusive milk diet can only be enforced for two or three weeks at a time; but it can be resorted to again and again, if it is beneficial. Some patients do not improve on it, notwithstanding the increased flow of urine, diminution of albumin, and lessening of the dropsy. The diet, therefore, must be more generous; but the adoption of a **purin-free diet** might be tried for a time, especially for gouty, granular and sclerotic kidneys. It should consist of milk, cheese, cream, butter, eggs, white bread, macaroni, vermicelli, tapioca, rice, sago, cabbage, cauliflowers, onions, potatoes, spinach, lettuce, fruit, sugar, and a little spirit, claret, Burgundy, or Volnay, with mineral waters. By way of change a meal of light fish or tripe may be allowed; but meat, fish, and fowl should be forbidden; also sweet-

bread, liver, kidneys, tea, coffee, coca, beans, lentils, asparagus, and malt liquors.

In other cases the return to ordinary diet should be in the following order: Tripe, fish, fowl, veal, lamb, mutton, beef. The excretion of water, albumin, etc., should be carefully watched, as well as the effects of the diet on the heart and bloodvessels. If an acute exacerbation occurs, the milk diet should again be resorted to.

If the patient is obviously past improvement, it is useless to attempt to influence the excretion of nitrogen and albumin by food. It is proper, however, to prescribe a light and nourishing diet, derived more or less from such articles as satisfy the patient's desires, care being taken that the heart and alimentary canal are not upset thereby, and no course is permitted which would be likely to shorten his days.

Dry Diet.—The restriction of fluids has been advocated as a means of reducing dropsy. There can be no doubt of its value in some cases; but it is obviously more suitable for granular and lardaceous diseases of the kidneys, where the dropsy is more cardiac or vascular than renal in origin. The restriction of fluids in distinctly renal dropsy would not be of any great value because of the retention of the waste products of metabolism.

The restriction of fluid to about 15 ounces a day causes a concentration of the blood, absorption of fluids from the tissue, reduction of pressure on the abdominal veins, diminution of the ascites, and increased secretion of urine; but such an extreme reduction of fluid is better reserved for those cases in which there is a distinct failure of compensation or dilatation of the heart. But on no account should a dry diet be prescribed without at the same time reducing the intake of salt. If this precaution is not observed, we may cause an accumulation of chlorides in the tissues, probably an increase of the œdema, or, at any rate, the œdema would not be reduced. In cases of acute nephritis or the subacute exacerbations which occur in chronic renal disease, especially of the tubular variety, the diminution of urine is due to the impermeability of the diseased organs. To give an excess of fluids in such cases would be likely to lead to the increase of dropsy and hydræmic plethora, besides increasing the work of the heart and probably causing a compensated hypertrophy to be transformed into a dilated hypertrophy. These, of course, are cases of true renal dropsy; if we permit the consumption of the ordinary amount of liquids in such cases, we must endeavour to provide for its elimination through the skin by hot-air or steam baths, acupuncture in the dependent parts, Southey's tubes, etc. But in many of these cases a temporary reduction of the fluid to 2 or 2½ pints daily may lead to an increased diuresis and a reduction of the dropsy. In chronic, tubular, or parenchymatous nephritis, even when there is no dropsy, there is a danger of overloading the circulatory organs and precipitating a failure of compensation, if the patient persists in taking too much fluid; this is one of the objections to the milk diet. Therefore, the

amount of fluids which should be allowed the patient, whether dropsy exists or does not exist in renal disease, depends upon the power of the kidneys to eliminate it, and of the heart to keep the tissues from becoming water-logged.

Salt-Free Diet.—The dietetic importance of sodium chloride has not been satisfactorily explained. According to Gautier, "it protects protein substances from disassimilation"—*i.e.*, it promotes assimilation—and its use, from this point of view, is economical. Bunge says the presence of sodium is essential to prevent the toxic effects of potassium. It plays an important part in the nutritive exchanges between the cells and the plasma, and stimulates the excretion of waste products by the kidneys (see the chapter on Vitamines). Absolute withdrawal of common salt from the food causes dehydration of the tissues, and this is the basis of the salt-free dietary. Salt is found more or less in all foodstuffs; the daily requirement is only 3 grammes (about 46 grains), but a healthy man on ordinary diet excretes 11 or 12 grammes daily. The excess consumed to suit the palate, under ordinary conditions, is eliminated by the kidneys; but the inability of the kidneys to excrete sodium chloride and other inorganic salts in chronic renal disease is well known. The presence of an abnormal amount of sodium chloride in the blood and tissues is one of the causes of œdema, but it is not the sole cause. The amount of chloride excreted daily in the urine averages 7·5 grammes; it is increased by the ingestion of ordinary food, muscular or nervous activity, and diminished by rest, fasting, and salt-free diet.

The retention of sodium chloride in the tissues is due to one of two causes—(1) the kidneys are unable to excrete it; or (2) it is chemically combined with the cells. According to Marie, this combination occurs in the preliminary stages of œdema, and he calls it *chlorure fixé*. But by-and-by the tissues become saturated with water, and the chlorides begin to accumulate in the surrounding fluids, and œdema rises in proportion to the retention; Marie calls this *chlorure libré*. Whether this explanation is satisfactory or not, this much is known: When water is retained in the tissues, it requires the presence of NaCl to balance the osmotic pressure of salt in the blood. The greater the retention of water in the tissues, the more NaCl will be accumulated therein and the less will be excreted in the urine. On the other hand, there are cases of Bright's disease, where the kidneys are unable to excrete salt, even when diuresis has been established; therefore it has become an established custom of many physicians to reduce the intake of common salt with the view of relieving the kidneys from the duty of excreting it or of preventing its accumulation in the tissues. The indication for salt-free diet is the **failure of compensation**, characterized by diminution in the excretion of water, a cloudy appearance of the urine, high percentage of albumin, poverty in chlorides, and excess of cellular elements, and a corresponding increase of body-weight, with or without perceptible œdema. In

compensated granular kidney, and even in many cases of chronic parenchymatous nephritis, the chloride equilibrium is well maintained—that is to say, the kidneys excrete a quantity of chlorides equivalent to the amount consumed; but even in these cases an occasional estimation of the chloride output is advisable, for there is a kind of invisible œdema, due to an accumulation of water in the interstitial and especially the deeper tissues, which causes an increase of weight without any perceptible œdema of the subcutaneous tissues.

The cases in which salt-free diet is useful, therefore, are those cases of chronic parenchymatous nephritis with œdema or dropsy, and granular kidney when there is a failure of compensation. Periodical weighing enables us to detect the formation of visceral and deep-seated œdema before the subcutaneous œdema becomes perceptible; but it is also advisable to compare the output of chlorides with the intake. There is such a thing as "dry retention" of sodium chloride, which is the same thing as Marie called *chlorure fixé*. This dry retention tends to cause an increase of arterial pressure, and, according to Widal, it may determine attacks of vomiting and diarrhœa, dyspnœa, Cheyne-Stokes breathing, or even epileptiform convulsions.

A salt-free or salt-poor diet may be constructed by using figures given by Strauss, as follows:

THE PERCENTAGE OF SODIUM CHLORIDE IN FOODS.

Raw Foods.		*Cooked Foods.*	
Milk	·15 to ·18	Poached eggs	·50
Butter: *Unsalted*	·02	Buttered eggs and omelettees	2·4 to 2·70
Salted	1·00	Roast beef	1·9 to 2·80
Cheese	1·5 to 2·50	Beef-steak	3·00
Egg: Whole	·14	White bread	·48 to ·70
White	·19	Brown bread	·75
Yolk	·02	Cauliflower, Mashed potato	·50 to ·91
Caviar	6·00 to 7·00	Asparagus	2·70 to 3·50
Meat	·10		
Cereals	·01 to ·10		
Rice	·01		
Oatmeal	·04		
Legumes	·01 to ·10		
Peas	·06		
Potatoes	·04		
Vegetables and salads	·10		
Fruit, not exceeding	·06		

In prescribing a rigid salt-free diet an attempt should be made to keep the amount of sodium chloride down to $1\frac{1}{2}$ or 2 grammes daily. This will mean the exclusion or reduction of the allowance of meat, fish, and meat broths; but as this is usually demanded on other grounds, it entails no greater hardship on the patient than forms of diet previously detailed. Ordinary bread contains 5 to 7 grammes of salt per pound, and milk 1 gramme per pint; sea fish contains much more salt than fresh-water fish. The proteins

should be derived from milk, eggs, chicken, cooked without salt, tripe, fresh-water fish, cheese made without salt, and bread made without salt. Milk can be taken alone or with eggs, in the form of custard, in puddings with rice, sago, oatmeal, etc. Eggs can be taken in many ways without the addition of salt—*e.g.*, custards, milk puddings, poached eggs, boiled eggs, omelettes; the latter can be seasoned with sugar instead of salt. Eggs can also be taken in "cream," soufflés, and sauces. Jellies made of gelatin or isinglass, and meat jelly are permissible. The fats should be derived from milk, eggs, unsalted butter, fat meat eaten without salt, cheese made without salt, cream cheese, and salad-oil. Carbohydrates may be obtained from sugar, treacle, golden syrup, jam, marmalade, *bread made without salt,* milk puddings without butter, blanc-mange, jelly, milk sauces, fruit, and vegetables. Bread and pastry made without salt are not unpleasant when eaten with stewed fruit, jam, marmalade, and unsalted butter. Vegetables should be allowed *ad libitum,* because they can be made the vehicle of flour and fat in the form of "white sauce." It is recommended that all vegetables should be cooked in plenty of water, with a *minimum* of salt, thereby reducing the proportion of inorganic constituents. No salt must be used when cooking or eating the food, except the small amount absolutely necessary to give flavour to potatoes, cabbages, and other green vegetables, and the salt must be put into the water in which they are cooked so that it permeates them by the process of diffusion. The absence of flavour may be obviated to a great extent by a careful employment of spices and condiments, such as mint, thyme, parsley, marjoram, savory, bay-leaf, chutney, horseradish sauce, tomato sauce, mustard, nutmeg, cinnamon, allspice, vanilla, lemon, cocoa, chocolate, and coffee, and in some cases a small amount of pickles, such as red cabbage, onion, or cauliflower. The liquids allowed are milk, whey, buttermilk, weak tea, cereal or fig coffee, lemonade, fruit juice, and aerated waters, or a small amount of wine or spirit and water. The following are examples of diet containing not more than 2 grammes of salt:

1. Balint prescribed: Milk 1½ to 2½ pints, butter 1½ ounces, three eggs, saltless bread 9½ to 12½ ounces, and weak tea or coffee; calories 2,300 to 2,400.

2. Cauducci prescribed: Milk 2½ pints, meat 10½ ounces, bread 10½ ounces; calories 2,200.

3. Achard and Widal drew up the following series of diets:

(1) Milk 1¾ pints, potaotes 10½ ounces, meat 10½ ounces, barley 7 ounces, sugar 1¾ ounces, butter 1⅓ ounces; calories 2,274.

(2) Bread without salt 7 ounces, meat 7 ounces, green peas or kidney beans 8¾ ounces, butter 1¾ ounces, sugar 1⅓ ounces; calories 2,200.

(3) Potatoes 35 ounces, meat 14 ounces, butter 3 ounces, sugar 3½ ounces; protein 110 grammes, calories 3,132.

(4) Potatoes 35 ounces, meat 10½ ounces, butter 1¾ ounces, rice 4½ ounces; protein 98 grammes, calories 2,295.

(5) Saltless bread 7 ounces, meat 14 ounces, butter 3 ounces, sugar 3½ ounces; protein 117 grammes, calories 3,037.

(6) Saltless bread 7 ounces, potatoes 24 ounces, butter 1¾ ounces, milk 35 ounces; protein 79 grammes, calories 2,450.

(7) Saltless bread 7 ounces, potatoes 10½ ounces, rice 3½ ounces, sugar 3½ ounces, butter 1 ounce; protein 33 grammes, calories 1,891.

(8) Saltless bread 1 pound, potato 1½ pounds, butter 1¾ ounces, white cheese[1] obtained by the coagulation of 1 quart of milk; protein 126 grammes, calories 3,220.

(9) Milk 2 pints, two eggs, meat 10 ounces, flour 2 ounces, sugar 1¾ ounces, butter 1¾ ounces; protein 125 grammes, calories 2,292.

The dietary can be varied considerably, but it must be carefully considered, so that the consumption of protein is neither above nor below the limits prescribed in these pages, as it is in some of the above-quoted dietaries. The following items would probably suit most English palates:

Breakfast.—Oatmeal porridge, saltless bread-and-butter, one or two eggs (poached or buttered), raw egg-and-milk; fresh-water fish, eaten with lemon juice or vinegar. Jam, marmalade; tomatoes, or other fresh fruit. Tea or cereal coffee made with water or milk.

Midday Meal.—Vegetable soup, saltless bread, cow-heel, tripe, unsalted tongue, fresh meat or fowl. Fish may be taken once or twice a week, with mayonnaise sauce, white sauce, or bread sauce. Milk puddings, creams, custard, junket, blanc mange, jelly, stewed fruit, salt-free biscuits, or crackers. Salt-free cheese. Green vegetables, kidney or snap beans, vegetable marrow, spinach, scorzonera, celery, cauliflower, and potatoes, all cooked without salt, or the *minimum* required to give flavour.

5 p.m.—Tea, with salt-free bread-and-butter, cakes, honey, marmalade, and other confections.

Evening Meal.—Any article from list for the midday meal or breakfast.

The salt-free, or hypochloride, diet, as it is sometimes called, presents several advantages over milk diet; but the chief advantage is variability of the diet compared with the monotony of milk. There are some disadvantages from the withdrawal of salt from the food; the part played by salt in maintaining an equilibrium between the fluids of the body is important. In certain depressed patients sodium chloride stimulates the metabolism and especially the functions of the kidneys between the periods of retention; another drawback is the difficulty of establishing a tolerance of the salt-free diet; it requires about two weeks to do this, but with some people it takes a longer period. The use of condiments assists in establishing tolerance; but we must watch the alimentary functions, for it is well-known that an excess of spices tends to upset them and leads to other disturbances, which may be deleterious to the nephritic patient. It is not advisable to maintain a strict chloride-free diet when it is ascertained that the kidneys are eliminating salt in a sufficient quantity—that is to say, when the chloride metabolism is maintained in equilibrium. But, inasmuch as there

[1] This is the same as Colwick cheese, straw cheese, new cheese, etc., but it is prepared without salt.

may be a sudden unforeseen impermeability of the kidneys to sodium chloride, it would be prudent to insist on the permanent reduction of salt, and to put the patient on diet which contains somewhat less salt than the amount tolerated—*i.e.*, than the amount which the kidneys can excrete.

The Influence of Baths on Metabolism in Chronic Nephritis.—In healthy persons, under the influence of free perspiration, more protein is digested, and the metabolism of nitrogen increases both quantitatively and qualitatively. In nephritic subjects the metabolism of nitrogen is lower in quantity and quality than in healthy persons. The amount of nitrogen in the perspiration of both healthy and nephritic subjects is small. In health it averages about 1 gramme per diem; it is for the most part in the form of urea, and is equivalent to 3 or 3·5 grammes of urea daily, or about one-ninth of that excreted by the kidneys. But Easterbrook[1] says the skin is a more important organ in the excretion of urea than it is generally considered to be. He made observations upon this function of the skin, and found that the excretion of urea by the kidneys varies, and the variations coincide directly with the activity of the skin. According to these observations the urinary urea reaches its maximum point of excretion between 2.30 and 10 p.m., and the cutaneous urea increases at the same time, the morning perspiration containing 0·1 per cent. and the evening perspiration 0·2 per cent. of urea. During severe muscular exercise the perspiration was increased in amount and the proportion of urea with it, while that of the urine remained normal; but during thirty-six hours after the exercise there was a rise in the urinary urea and a corresponding fall in the sweat urea. The cutaneous urea is always increased by exercise, but the urinary urea is unaffected at the time of the exercise, although it increased for a day or two after it.

The principal effect of baths is usually considered to be increased excretion of water, salts, and probably toxic principles by the skin; but the evidence of Easterbrook is in favour of the opinion that both hot-air and hot-water baths are a powerful means of ridding the organism of nitrogenous waste bodies as well as salts. The evidence is of sufficient importance to suggest the strong recommendation of frequent bathing and the wearing of warm clothing to keep the cutaneous functions in activity, and to encourage the patient to take exercise, which will also increase the perspiration and cutaneous excretion of urea, salts, and other waste products.

[1] *Scottish Med. and Surg. Jour.*, 1900, p. 120.

CHAPTER XIII

GOUT AND RHEUMATISM

Gout.

It was shown by Garrod (the elder) that the blood of gouty persons contains an excess of uric acid in the form of sodium quadriurate, and the urine an abnormally small amount. This accumulation may be due to excessive production or diminished elimination of uric acid; both factors occur in many cases. Three types of gout are recognized by Schittenhelm[1]: (1) Metabolic gout, (2) renal gout, and (3) a combination of the two. The metabolic type is characterized by uricæmia, defective general metabolism, a subnormal output of endogenous uric acid, and delayed metabolism of exogenous uric acid. In the renal type there is also uricæmia and defective metabolism of nuclein bases; but renal and cardio-vascular changes are prominent; and the gouty manifestations are more or less proportionate to these changes It is, in fact, due to **retention uricæmia.** How and where uric acid is produced belongs to physiology.

Uric acid is one of the nuclein or purin bodies which are closely related—viz.: Purin, hypoxanthin, xanthin, uric acid, adenin, guanin, heteroxanthin, paraxanthin, theobromin, and caffein. *Exogenous purins* are those contained in our food; *endogenous purins* those derived from the metabolism of the nucleins and nucleo-proteins of blood and tissues. A number of intracellular enzymes combine to transform them into allantoin or urea. *Proteases* split nucleo-proteins into protein and nuclein, and the latter into protein and nucleic acids; *nucleases* liberate adenin and guanin from the nucleic acids; specific *amidases* (guanase and adenase) deprive these amino-purins of their amide group (NH_2)—guanin becomes xanthin, and adenin becomes hypoxanthin; various *oxidases* transform hypoxanthin into xanthin, and xanthin into uric acid; and finally uric acid is decomposed by uricolytic enzymes, the end-product being either allontain or urea. These intracellular enzymes are of the greatest importance in metabolism. They occur in the cells of the liver, spleen, kidneys, muscles, and other tissues. The liver destroys uric acid to a considerable extent, and according to most authorities the kidneys of the human subject have a greater uricolytic power than the liver. The fasting liver has not the same power as the liver during digestion to decompose urates, which shows what a powerful factor the liver may be in causing metabolic gout. The experiments showing that the human kidneys destroy more uric acid than the liver are held to be in favour of the renal origin of gout. But the muscles destroy more uric acid than the liver and kidneys together, their relatively great bulk making up for the smaller uricolytic power of an equal weight of tissue. This explains why regular exercise relieves so many symptoms of uricæmia.

[1] "Gicht u. uratstein diathese," Brugsch and Schittenhelm, Jena, 1910.

The theories respecting the origin of gout are as follows: (1) *The retention theory*—namely, that gout is due to the diminished excretion of uric acid by the kidneys; (2) *the excessive consumption theory*—namely, that gout is due to the excessive consumption of animal foods containing proteins and purins; (3) *the defective metabolism theory*—namely, that gout is due to diminished oxidation in the tissues—that is, defective metabolism in the organs and muscles, arising from the deficiency of oxygen and catalytic enzymes.

These theories have been discussed widely, and much evidence has been derived from experiments and used by the supporters of each. But the " rock bottom " of the trouble is a disturbance of the alimentary canal, probably a catarrhal condition of the mucosa of bacterial origin, leading to the production of toxins which may cause the defective metabolism of proteins and purins, and set up a degree of chronic nephritis leading to retention. The formation of such toxins is favoured by an excessive consumption of protein or alcohol, and the accumulation of toxins goes on until it culminates in an attack of gout. Few, however, doubt that gouty individuals possess some inborn defect, which lowers the resistance of the tissues to irritation, which is not possessed by persons who do not exhibit a gouty tendency. In such persons a slight injury, an indiscretion in food or drink, an overloaded intestine, may be followed by a disturbance of the metabolism, and provoke an attack of gout. " This suggests the idea," says Walker Hall,[1] " that the nuclein metabolism of the gouty is run at high pressure, which may be only half or a quarter the normal capacity, and there is very little reserve energy. If we admit this conclusion—and it is warranted by the facts ascertained—we have the analogy of other high-pressure conditions as a guide in prognosis and treatment. The regulation of the nuclein or purin intake to the capacity of the individual and the conservation of the nuclein metabolism are called for."

The Treatment of Gout.—1. **Acute Gout.**—The dietary during an attack of acute gout should be meagre. For the first day *water diet* only ought to be allowed. It should consist of an abundance of plain hot water, barley-water, oatmeal-water, Imperial drink, soda-water, potash-water, Apollinaris, Perrier, Salutaris, Vals, Vichy, Ems, or other waters of the same character. On the second day *milk-and-water diet* may be allowed. It should consist of 2 pints of milk, divided into small doses, and diluted with whey, buttermilk, barley-water, oatmeal-water, or one of the other waters named above. On the third day he may have 3 pints of milk divided and diluted as before, a cupful of weak tea twice a day, and a slice of dry crisp toast, well buttered. This diet must be continued so long as any signs of acute inflammation remain. No alcohol ought to be allowed, unless there is definite evidence of cardiac weakness, and even then it may profitably be replaced by drugs. If alcohol is prescribed, a little well-matured whisky or brandy is preferable

[1] *Practitioner*, 1909, ii. 112.

to other forms. On no account ought beef-tea, chicken broth, soups, meat essences or jellies to be allowed.

The transference to *fish diet* is begun when the acute symptoms have subsided, some sole, plaice, or whiting, with dry toast and butter and a sprinkle of lemon-juice over the fish, being allowed first of all. This may be followed by a spoonful or two of rice, sago, or tapioca pudding, or boiled macaroni and tomato sauce. The next day a poached or lightly boiled egg, with dry toast and butter for breakfast; fish, some well-cooked vegetable, and milk pudding or fresh fruit for the midday and evening meals. A regular dietary is to be built up by easy stages. Care must be taken to avoid all indigestible and other articles forbidden to the gouty (see below).

2. **Chronic Gout and Goutiness.**—The indications are to remove the causes of metabolic derangement and reduce the purin or nuclein intake to the capacity of the organism for dealing with it.

A faulty regimen is probably the cause of the metabolic derangement. Disorders of the gastro-intestinal tract and liver are most important factors in gout. It behoves us, therefore, "to put the house in order." Sufficient instruction has been given in the chapters on gastric, intestinal, and hepatic disorders; but a brief summary may be desirable.

(1) The gastro-intestinal mucous membrane is easily irritated by an excess of fibrous tissue. The gouty person should exclude from his dietary all tough meat; skin and gristle should be cut out of all meat, poultry, or fish. Fibrous vegetables and those containing much cellulose should also be excluded.

(2) A large amount of organic acids is equally injurious by irritating the mucosa and causing gastro-intestinal catarrh. These acids are a common factor in producing gouty dyspepsia and acidity. The late Milner Fothergill used to recommend a drachm of bicarbonate of potash to be put to each pound of fruit when it is cooked. This has the double advantage of neutralizing acids and reducing the quantity of sugar required. Vinegar and other forms of acetic acid are injurious; therefore pickles must be avoided. Luff recommends people with gouty eczema to avoid strawberries, gooseberries, cranberries, apples, lemons, pineapple, and rhubarb (*pie-plant*). Lemon-juice is considered good for gout and rheumatism, but the citric acid is a local irritant to the mucosa, and it may do more harm before it leaves the alimentary canal than good after it is absorbed. If fruit does not irritate the mucous membrane, it will be very beneficial to the gouty individual. Dyce Duckworth says: "Fruit has been condemned for very inadequate reasons; a moderate amount of raw or cooked fruit may be allowed, apart from the meals, not only with impunity, but with benefit."

(3) *Carbohydrates.*—These are very prone to fermentation, with the production of irritating acids, and are a common cause of gouty dyspepsia. It is better, therefore, for a time to cut down the allowance of carbohydrates, especially sugar and sweet foods, and

prescribe malt extract, or takadiastase after a meal containing them, to assist in the transformation of starch.

(4) *Fats* are very useful foods for the gouty to make good the deficiency from the restriction of carbohydrates. But their consumption must be watched. Foods fried in fat are bad, because *acrolein*, produced by heating the fat, is injurious. Butyric acid, often present in remarkable proportion in cooking butter, is very injurious. If there is a suspicion of hyperchlorhydria, the use of fat bacon, ham, pure butter, cream, olive-oil, and good salad-oil, will restrain the secretion of HCl, and so far are beneficial. If there is a suspicion of hypochlorhydria, the fats should be reduced as much as possible.

(5) *Spices and Condiments.*—An excess of these substances causes or aggravates congestion of the mucosa, leads to hyperchlorhydria, catarrh of the mucosa, hyperæmia of the liver, and a disturbance of absorption and metabolism. A very moderate amount of salt, pepper, and mustard may be allowed; but curry and other spiced foods, sauces, and relishes must be forbidden.

(6) *Alcohol* should be forbidden theoretically, owing to its injurious effects on the alimentary organs, especially the liver, and metabolism in general. But a few persons are benefited by a small allowance of alcohol. This will be referred to later.

The second indication is to reduce the nuclein metabolism and intake of purins to the capacity of the organism for disposing of them. This may be done by giving a low purin or purin-free diet. A table showing the purin bodies in food is given on p. 226.

Purin-Free Diet.—According to Walker Hall, there is no purin in milk, butter, cheese, cream, eggs, flour, white bread, macaroni, rice, tapioca, sugar, cabbage, cauliflower, or fruit, and a combination of these form a purin-free diet.

A *low purin diet* consists of the same articles, with the following additions: Tripe, codfish, neck of pork, very fat ham or bacon, potatoes, onions, and practically all fruits and green vegetables. Puddings may consist of milk, sugar, eggs, rice, sago, tapioca, and macaroni or flour; custards, junkets, jellies, and suet puddings. Beverages may consist of plain water, hot water, aerated and mineral waters, with a little claret (Volnay), Burgundy, whisky, or gin. The patient should be prohibited from taking butcher's meat, game, poultry, tea, coffee, cocoa, beer, and stout. Haig, who is one of the chief supporters of the purin-free diet, says the following diet is free from uric acid, and would yield 1,400 grains (90 grammes) of albumin, enough to meet the daily requirement.

PROTEIN-FREE DIET TO SUPPLY ALBUMIN.

10 ounces of white bread contain	.. ..	344 grains
2 ,, oatmeal ,,	.. ..	104 ,,
2 ,, rice ,,	.. ..	43 ,,
2 pints of milk ,,	.. ..	381 ,,
12 ounces of vegetables and fruit contain	..	103 ,,
Total	.. ..	1,400 ,,

The chief trouble in carrying out the purin-free dietary is with regard to lunch and dinner. The following were framed by one of Haig's disciples:

PURIN-FREE DINNERS.

FIRST DAY—*Lunch.*—Green vegetables, baked potatoes, butter; stewed figs, ½ pint of junket; 2 ounces of pine-nut kernels (grated), with whipped cream.

Dinner.—Biscuits, butter, 1 ounce of grated cheese or some milk curds; light pudding, stewed fruit and cream.

SECOND DAY—*Lunch.*—Green vegetables, potatoes with butter, cheese sauce, and dry toast; fruit tart with cream; ½ pint of milk.

Dinner.—Two boiled eggs, biscuits and butter; milk pudding containing ½ pint of milk; stewed fruit and cream with biscuits.

THIRD DAY—*Lunch.*—Potatoes and butter, green vegetables or salad; pudding or "cutlet" made of 2 ounces of ground nuts; stewed fruit and cream with biscuits.

Dinner.—Biscuits and butter, with cheese soufflé or omelette; stewed fruit and cream with biscuits; roasted chestnuts.

It must be recognized that purin-free diet is only a temporary measure; moreover, it is usually a low protein diet, and the physician must see that the proteins consumed do not fall below 80 or 90 grammes a day. After one or two months, the diet should be improved. The first additions may with advantage be from the vegetable kingdom—lentils, peas, beans, and nuts. After two or three months of this diet, we may add *boiled* fish (sole, plaice, whiting, turbot, cod, and fresh haddock), tripe, neck of pork, and fat ham. Part of the meat bases and purins will be washed out during boiling of these foods. Some writers say the first meat allowed should be sweetbread, because the purins in it are "bound purins." I fail to understand what is meant by this phrase. If it means that the purins are bound up with the nuclei of the cells, and such nuclei resist digestion more than the cells of muscular tissue, it is certainly in favour of sweetbread. But is it correct? Sweetbread contains more purins than any other organs. Moreover, Walker Hall found that 60 to 70 per cent. of those purins were absorbed, and at the most 40 per cent. escaped absorption, and were voided in the fæces. Burian and Schurr also found sweetbread gave rise to a larger output of purins in the urine than any other food. According to Lilienfield, the composition of thymus gland (*neck sweetbread*) is—Proteins 17·6, leuco-nuclein 687·9, histon 86·7, lecithin 7·51, cholesterin 44, fat 40·2, glycogen 8, parts per 1,000. The composition of pancreas (*stomach sweetbread*) is similar. I should therefore never recommend sweetbread (either thymus or pancreas) to be consumed by gouty people at any time. Nor should the spleen be eaten or taken in soup or gravy by such people.

When ordinary diet is resumed, the additions should be made gradually. First allow boiled leg or loin of mutton, boiled rabbit or fowl (the breast of birds contains less extractives than the wings or legs), pigeon, breast of turkey, well roasted rib of beef; sirloin and steak of beef should be added last of all. The following articles

should be permanently excluded: Veal, pork (except neck), goose, duck, high game, and greasy foods.

Many writers exclude tea and coffee from the diet on account of the caffein. Burian and Schurr state that coffee contains 0·2 per cent. of purins, and causes an excretion of 0·075 per cent. in the urine. But it is unnecessary to exclude these beverages, owing to this small amount of purin, if the right kinds are used and the beverage is properly made. China tea is better than Assam, Indian, or Ceylon tea, because it contains less tannin. Coffee should be taken with chicory, or coffee deprived of caffein may be used; also dandelion coffee, acorn coffee, fig coffee, postum coffee, etc. Luff says: "It is erroneous to exclude tea, because it contains uric acid." Duckworth says: "Tea, coffee, and cocoa, properly prepared, are harmless. The greatest consumers of them know nothing of gout; but strong black coffee after meals is not advisable."

Certain vegetables contain purin bodies and amide nitrogen, which are normally converted in the body into urea. These include asparagus, mushrooms, spinach, peas, and beans, and as a rule they should be prohibited.

Is a purin-free or low purin dietary useful to the gouty person? Most certainly it is. If gout is due to the defective metabolism of nuclein or purin bodies, these substances ought to be kept out of the diet until the organism recovers its powers of transforming them to urea. If gout is due to some disease of the kidneys preventing their elimination, there is an equally powerful argument for their exclusion. Haig has inculcated the use of a purin-free diet for many years. Burian and Schurr made observations showing its utility. Walker Hall recommends it in consequence of his experiments. Brugsch and Schittenhelm have made equally important observations proving its value. But the diet doubtless has limitations, and these have been discussed by Bryce and others. It is not a panacea, and in gout its use is limited by the nature of the disease. If exogenous or food purins are badly metabolized, the endogenous or tissue purins are equally badly metabolized.

Low Protein Diet.—It is frequently observed that a gouty person does better on chicken, fish, and other white-fleshed foods than on red meat. This is considered a proof that purin bodies alone are not responsible for the evil effects arising from animal food. Chicken and turkey contain more purin bodies than ribs of beef, halibut and trout more than mutton. The greater danger arising from beef and mutton is due to the fact that a gouty person does not digest their long muscular fibres so easily and thoroughly as the shorter fibres of chicken, rabbit, and fish. A careful consideration of all the points of the purin-free diet leads to the conclusion that it is a **low protein** diet, and many authorities believe that the curative effect is due to this cause. Many physicians find there are only a few cases of gout where a moderate quantity of animal food does harm, and many where it does good.

The **restriction** of animal food is necessary. But it must not

be carried too far. Even Haig, one of the chief supporters of the purin-free diet, says: "My results have led me to believe that 90 grammes daily is required"—*i.e.*, a quantity of protein intermediate between Chittenden's low protein standard and the standards of the older writers. I have fully discussed this matter in the chapter on Food Requirements, and concluded that the allowance of protein ought not to be below 1 gramme for every kilo, or ½ gramme for every pound of body-weight, and that about one-half of it should be derived from animal sources. I see no reason for departing from this rule in treating the gouty. Duckworth says: "With respect to animal food, it is not only harmless, but beneficial to gouty persons if taken in moderation. . . . The notion that white meat is permissible, and red is not, probably came from the Continent, where the ordinary white meat is veal. This is a very different and superior article from any that can be procured in this country, while the beef and mutton are very inferior in texture and flavour to the products of Great Britain and her colonies." In so far as the discussion on purin-free diet makes for simplicity, it has done much good. But meat, even red meat, should not be excluded from the dietary. No class of foods is so productive of energy as animal food, and as many subjects from chronic gout suffer from want of tone or lowered vitality, a moderate quantity of meat is distinctly indicated for them. *Meat should be taken once a day,* preferably at the midday meal. It may consist of chicken, boiled fowl, stewed rabbit, occasionally game, mutton—especially shoulder and loin—tender beef (sirloin or ribs), and fresh fish of the white kinds only. Some fat boiled ham or toasted bacon may be taken for breakfast, and this may be varied by eggs or fish once or twice a week. Prohibit liver, sweetbread, pickled and salted meat, rich gravy and sauces. Only half the protein should be derived from animal foods. The following are examples of how it may be provided:

1. Chicken, pheasant, breast of turkey, guinea-fowl, pigeon, or rabbit; 3½ ounces of any one of these would supply from 22 to 26 grammes of protein for the midday meal. One egg or ¼ pint of milk with porridge for breakfast would make 29 to 32 grammes.

2. Fish: 5½ ounces contain approximately the amount of protein following the names: Sole 17, plaice 17·5, turbot 23, cod 25, haddock 26, bass and halibut 28, grammes.

3. Mutton: 3½ ounces of roast leg contain 25 grains of protein, An egg yielding 7 grammes for breakfast would bring the total up to the limit.

4. Beef: 3½ ounces of beef, containing an average amount of fat, would represent 25 grammes of protein. An allowance of 2 ounces of fat ham or bacon for breakfast would bring up the total.

5. One egg (7 grammes protein), with 2 ounces of fried bacon (5½ grammes protein), for breakfast, and 5½ ounces of sole or plaice for lunch or dinner would make a total of 30 grammes.

6. A fillet of plaice or haddock for breakfast, and 2 ounces of

rather fat beef or mutton for dinner would contain 30 grammes of protein.

7. Oatmeal porridge, with ¼ pint of milk and a poached egg for breakfast, with 2½ ounces of chicken, turkey breast, pheasant, partridge, pigeon, or rabbit for lunch *or* dinner, would contain 30 grammes of protein.

The idea is to give one meat meal a day. The rest of the protein is to be derived from vegetable foods—*e.g.*, 4 ounces of white bread or roll contains 8 to 10 grammes of protein, ordinary brown bread rather less, and wholemeal bread rather more. An ordinary helping of milk pudding contains 4 to 7 grammes of protein, according to the presence or absence of eggs.

If pulses or legumes are consumed, they should be taken in place of meat; they contain nuclein or purin bodies in about the same proportion. Two ounces of dried haricot beans contain 13 grammes, of dried peas or lentils 16 grammes of protein. These amounts are as much as the patient would eat at a meal. Nuts occupy the same position as pulses: 2 ounces peanuts contain 19 grammes protein, almonds 16, walnuts, filberts, or Brazil nuts 12, and chestnuts 9 grammes. They ought to be ground in a mill, and peanuts and chestnuts should be cooked.

The Protein Fast.—In the treatment of gout it is advisable to insist on a fast-day once a week. On these days the food should consist entirely of bread or toast and butter, vegetables, and fruit. No animal food, milk, cheese, pulses, or nuts, should be taken. The object is to rid the system of superfluous floating proteins and the débris from metabolism. There is no need for hunger on these days; indeed, such a system would be absurd. Water, tea, mineral waters, may be taken.

Exclusive Meat Diet.—An excess of animal food as a general rule is bad for the gouty. Nevertheless, there are certain cases which do not improve very much on the dietaries previously given. In these cases a course of Salisbury diet—lean meat and hot water—may be beneficial by reducing the diet to the greatest possible simplicity. The cases in which it is indicated are—(1) Obstinate cases of chronic gouty arthritis; (2) recurrent uric acid calculi; (3) gouty headache of the nature of migraine; (4) persistent gouty dyspepsia; (5) amylaceous and intestinal dyspepsia in gout. Under this treatment indigestion is cured, the fermentation and putrefaction in the intestines cease, and metabolism is improved. It is followed by a disappearance of urates and toxins from the urine; joint swelling diminishes, pain becomes less, and mobility increases. The dietary has been detailed elsewhere (p. 210). It may be continued for eight or ten weeks, during which no carbohydrate should be allowed, but merely lean meat and hot water.

Sour-Milk Treatment.—Many cases of gout, attended by alimentary toxæmia, may be considerably relieved by a course of sour milk. The various forms of sour milk—leben, yaourte, koumiss, and kephir—are purin-free. Its supporters also claim that

it is bactericidal, and reduces the number of putrefactive organisms in the alimentary canal. This statement is borne out by observations on monkeys and cats. By means of experiments, Herter and Kendal[1] showed they could produce a change in the bacterial flora of the intestines by abruptly changing the diet from an exclusive protein to an exclusive carbohydrate diet, or *vice versa*. On a protein diet the flora were mainly of a proteolytic character, and on a carbohydrate diet they were mainly of a non-proteolytic and acid-producing character. With the change to the acid-producing flora there was a reduction in the amount of indol, skatol, and phenol in the fæces and indican in the urine. It is said that the sour-milk treatment has the same effect. The accompanying diet should consist only of bread-and-butter, cooked vegetables, and fruit. A little roasted or grilled meat, fat ham, or bacon, may be allowed now and then, and, in some cases, a glass of good red wine after meals. In the majority of cases 4 ounces of sour milk should be taken just after the meal, and this should be gradually increased until 2 pints or more are taken daily. The strictness of the diet and length of the " cure " must depend on the effect produced.

Vegetarian Diet.—It is said that gout seldom attacks people who live on vegetable diet. The inhabitants of Scotland, who consume little animal food, and whose national beverage (whisky) contains no acid, are rarely afflicted with gout; but their immunity only lasts so long as they keep to their national beverage and diet. The sufferers from gout are principally those who have consumed much animal food and drink wine freely. Hence a vegetarian diet has been suggested as proper for gouty persons. The arguments of the vegetarians are that the salts of meat diminish the alkalinity of the blood, the salts of vegetables increase it—one causing a precipitation, the other a solution of urates. Animal food, they say, contains uric acid or its congeners, and tends to an accumulation in the blood; vegetable foods diminish the uric acid in the body. But these assertions are not supported by fact. Klemperer[2] found by experiment that—(1) The alkalinity of the blood of gouty persons is diminished very little, if any; (2) corresponding variations of alkalinity are found in healthy persons; and (3) a diminution of the alkalinity occurs in diseases in no way associated with the precipitation of uric acid—*e.g.*, acute rheumatism, leukæmia, diabetes, carcinoma, and pyrexia. Luff[3] says: (1) The solubility of uric acid in the blood is not affected by diminished alkalinity; (2) the deposition of sodium biurate is not accelerated by a diminution of the alkalinity of the blood; and (3) increased alkalinity of the blood does not increase the solubility of the deposits of sodium biurate. But vegetables are good for the gouty. It has been proved that the ash of vegetables has a greater solvent power over sodium biurate than the ash of meat or milk. Luff found that the

[1] *Jour. Biochem.*, February, 1910.
[2] *Deutsch. Med. Woch.*, 1895, xxi. 655. [3] Goulstonian Lectures, 1897.

presence of 0·05 per cent. and over of the mineral constituents of nearly all vegetables appreciably increases the solvency of sodium biurate. This is true of Brussels sprouts, French beans, spinach, savoy cabbage, winter cabbage, cauliflower, turnip-tops, seakale, asparagus, lettuce, celery, beetroot, turnips, carrots, and potatoes. The ash of green peas has no influence on its solubility. The solvent effect of the ash of Brussels sprouts, spinach, seakale, and potatoes, is high, of celery and turnips low. But the effect has no relationship to the alkalinity of the salt or its solution. Artificially prepared salts have not the same effect as the natural salts.

Uric acid first appears in the blood as sodium quadriurate. This is an unstable body, gradually transformed into sodium biurate, a comparatively insoluble substance, which forms the uratic deposits of gout. Luff investigated the effects of vegetable salts further. He found that the ash of spinach, Brussels sprouts, French beans, cabbage, turnip-tops, and turnips delays the transformation of quadriurate into biurate of sodium; on the other hand, the salts of meat diminish the solubility of sodium biurate, and have little influence in preventing the transformation of quadriurate into biurate of sodium. Hence all the fresh vegetable foods named above, if taken in sufficient quantity, would probably delay an attack of gout, and would certainly help to cure gout and goutiness.

But the vegetarian diet usually includes dried peas, beans, lentils, nuts, and fruit. It ought, therefore, to be pointed out that all seeds contain a considerable proportion of nucleins, nucleo-proteins, and amino-acids; they are not purin-free. Their only redeeming feature, so far as the gouty person is concerned, is that these foods are comparatively indigestible, the loss of protein by non-absorption from legumes and nuts being from 20 to 30, or even 40, per cent. The vegetarian diet, therefore, is a low protein diet. I fail to see any advantage to the gouty from this on the score of metabolism. If the gouty man is to have nucleins and purins in his food at all, he may as well have them in a mixed diet. Bain says: "A diet consisting largely of peas and beans is capable of producing more purin-bodies than one composed of animal foods; gouty patients should be advised to eat sparingly of them. Those who advise a vegetarian diet for the gouty do not take a correct view of these facts." Duckworth says: "On theoretical grounds a purely vegetarian diet is extolled by some as a means of averting gout. Such a diet is condemned by physiology, and no less by common sense." Vegetarian diets usually contain far too much carbohydrate, and the consumer is forced to deal with a far greater bulk of food than is necessary. Hueppe compared the body of a vegetarian to an overheated steam-engine, which is in danger of exploding from using the wrong kind of fuel. Luff says: "The contention that meat is poisonous to the human body on account of the uric acid it contains is preposterous. If meat is the poison a certain class of fanatics would have us believe it to be, we as a nation would have ceased to exist long ere this."

Beverages.—A gouty man should drink from $2\frac{1}{2}$ to 3 pints of fluids a day. The consumption of plain water may be encouraged. Water-drinkers or teetotallers proverbially have a large appetite, and are apt to take an excess of food. It is absolutely necessary, therefore, to insist that the gouty person must not drink a large amount of water or other fluids with the meals. If he eats his food dry, he will consume less; but what he eats will be better masticated and mingled with saliva. The patient should drink $\frac{1}{2}$ pint of hot water slowly while dressing in the morning. At breakfast he may have one cupful of tea, coffee, or cocoa. Half a pint of hot water should be taken before the midday meal; at the end of the meal he may have a glass of wine or a small amount of well-diluted spirit, if these are permitted. At 4 or 5 p.m. he may have $\frac{1}{2}$ pint of hot water or weak tea; and, finally, $\frac{1}{2}$ pint of hot water at bed-time. The water may be plain, distilled, or alkaline. Water containing much lime is said to be injurious, but if this is so, why send our patients to Buxton or Contrexéville? Water containing iron is also said to be injurious. Lithia, potash, Apollinaris, and similar waters may be taken for a few weeks, but not constantly; there should be a variation.

Cream of tartar (potassium bitartrate) makes a pleasant acidulous drink. A saltspoonful (about 20 grains) may be taken in a tumblerful of hot water with a little lemon-juice, and sipped slowly. The water should be boiled to precipitate excess of lime, or distilled water may be used. Edmunds[1] says cream of tartar rapidly clears the system of urates by the formation of nascent potassium bicarbonate in the system.

Theoretically, gouty people should take no alcohol, and most of them are better without it; it makes for faulty metabolism. But some people are better for a small allowance of good alcohol taken with one meal a day. The quantity must be less than what a healthy person can oxidize. Our working rule limits a healthy man's allowance to 2 ounces of absolute alcohol a day. Many gouty people have been in the habit of consuming regularly $\frac{1}{2}$ pint to 1 pint of whisky, containing 5, 8, or even 10, ounces of absolute alcohol. It is clear that their alcohol-oxidizing capacity was originally more than 2 ounces a day. It is rarely possible, when Nemesis, in the form of gout, renal, or hepatic disorders, comes to such people, to induce them to abstain, and not often that they will limit the intake to less than 2 ounces. All we can do is to preach the 2-ounce limit, and endeavour to persuade them to keep within it, and, if possible, induce them to reduce it to a little wine or spirit with one meal a day. As a rule what these men take with their dinner or supper does them no harm. It is the irregular drinking between meals which does the mischief. Sir Dyce Duckworth says: "A little good wine is certainly helpful to many elderly patients, but from 2 to 6 ounces is sufficient for them at one meal. The wines of Burgundy, the Midi district, Algeria, Hungary, Cali-

[1] *Brit. Med. Jour.*, 1900, i. 1404.

fornia, and Australia, are *unsuitable* for the gouty. Claret, as grown in the Bordeaux district only, and taken with water, is one of the safest wines to employ; it may disagree in some cases, but it is more often because half a bottle is taken when two glasses would suffice and be well disposed of. The same may be said of wines of the Moselle. There is little, if any, difference to be noted in the effects of red and white wine as far as the gouty are concerned. But Chablis is preferable to Sauterne, and contains less sugar. The best qualities of champagne, ten years old, and not too dry, suit many gouty patients well, if taken occasionally; but the rule as to quantity must be observed, and no mixing of wines at any meal. A little mature port wine is often borne very well by gouty patients. I know of no special virtue in what is called "tawny" port, sometimes vaunted as "safe" for such persons. Many gouty patients are intolerant of the smallest quantity of any of these wines. Therefore there is no fixed rule in respect to the kind of wine for the gouty. There can be no such rule. . . . British gouty persons are often urged to take whisky in place of other alcoholic beverages. There is no reason why brandy should not also be used. In any case the quantity must be small, and should never exceed 2 ounces, well diluted, and taken only at one meal a day."[1] Cider is sometimes prescribed, but it is not suitable for all. The best test is that of personal experience. If the consumption of cider has ever been followed by an attack of arthritic gout or gouty manifestation, it is not suitable for that person. It should be "rough cider," well fermented, and free from sugar. Such cider has not the injurious effects of sweet and highly alcoholic wine. On the other hand, sweet cider, champagne cider, and other artificially prepared forms may excite gout. The prevalence of gout in Devonshire in former days is attributable to lead-poisoning, from cider being stored in leaden vats; the consumers became the subjects of saturnine gout. Such vats are not used nowadays. The organic acids of cider are not innocuous, and occasionally give rise to gouty dyspepsia. Malt liquors should not be taken by the gouty. Like sweet wines, they are hostile to gout, and the usual explanation is that when sugar and alcohol meet in the stomach, they become mischievous. The **sugar** in wine is as follows: Bordeaux and Burgundy 0·14 to 0·21, Pommard 0·23, Hungarian 0·23, Moselle 0·25, Beaune 0·30, Australian 0·36, Chablis 1·20, champagne 1·92 to 2·5, port and sherry 5 to 7·5 per cent.

The **acidity** of wine is not in proportion to its gout-producing property. Luff, Garrod, and others do not believe the acids have much to do with the production of gout. The total acidity and gout-producing power are compared in the following columns. The first is from my own tables;[2] the second by Sir A. E. Garrod:

[1] *Practitioner*, July, 1909.
[2] Tibbles, "Foods: their Origin, Manufacture, and Composition."

Total Acidity of the Liquid.	Per Cent.	*Gout-producing Power, beginning, with the most Powerful.*
Moselle	1·064	Port.
Hock	·714	Sherry and other strong wines.
Madeira	·620	Champagne.
Burgundy	·415	Stout and porter.
Sherry	·411	Strong ale.
Claret	·316	Claret.
Strong ale	·310	Hock.
Lager beer	·170	Moselle.
Champagne	·150	Weaker ales.
Port	·140	

This arrangement shows the most acid liquors are not the greatest producers of gout. The greatest producers are port, sherry, and other strong wines, and ale and porter; the least are claret, hock, Moselle, and weak ales. The strongest producers of gout are those containing most sugar and alcohol, which favours the idea that the injury is produced by a combination of sugar, alcohol, and acids, and that they disturb the colloid constitution of sodium quadriurate, and throw it out of solution.

The Mineral Waters.—The employment of mineral waters in the treatment of gout is of great antiquity. But the treatment at the spas and hydropathic establishments is complex, and it is difficult to apportion the benefit derived from drinking the waters, the massage, baths, and electrical treatment. The natural mineral waters, one and all, differ from the normal characteristics of ordinary drinking-water by reason of their containing an excess of certain mineral constituents and radio-active bodies, such as argon, helium, and radium, and other gases. The curative effect of such waters is out of all proportion to the mineral constituents, judging from chemical analysis. It is an error to suppose that the total effects of such waters can be expressed in terms of sulphate of magnesia, lime, barium, etc. If they did, it would be a simple matter to prescribe these salts. Artificial solutions are not equivalent to those prepared in Nature's laboratory. A tumblerful of Friedrichshall water contains 24 grains of magnesium and 20 grains of sodium sulphates with 30 grains of sodium and 19 grains of magnesium chloride. It is a curious fact that an artificial mixture of the same strength has not the same effect as a tumblerful of the natural water. What constitutes the difference ? It is well known that all dilute solutions contain ions or dissociated particles of matter, and that such ions are charged with electricity, and have a great influence over the physiological processes of the body. The more dilute the solution, the more ions it contains. Most of the natural waters contain radio-active bodies. The radio-activity is a measure of ionization of the metals in solution. These points explain the difference between natural and artificial mineral waters. Bourdon exclaimed: "To give the name of 'Vichy water' to a solution of bicarbonate of soda is as absurd as to give the name of 'wine' to a mixture of alcohol, cream of tartar, and other salts,

which wine is proved to be when analyzed. Go to the natural springs; Nature is far better than the laboratory."

The alkaline treatment of gout was formerly in the forefront. The alkaline waters of Contrexéville, Evian, Vittel, dilute the liquids in the tissues, prevent the precipitation of uric acid, dissolve concretions, and assist in their removal. It was formerly believed that the alkalinity of the blood was diminished in gout, that alkalies increased the alkalinity and promoted the solution and elimination of uric acid. It is now known that the alkalinity of the blood is not diminished, and that the normal alkalinity of the blood cannot be increased by alkalies. The waters of Buxton, Wildungen, Evian, Vittel, and Contrexéville contain sulphate and carbonate of lime. They are powerfully diuretic, and some of them slightly purgative. They are anti-gout, not so much by what they bring into the body as by what they take out. They wash out the blood, liver, and kidneys, removing urea, uric acid, creatinin, and all other waste products of metabolism which have been accumulating in the system, and markedly improve the metabolism of proteins.

Saline waters also have a reputation for the relief and cure of gout and gouty rheumatism. They contain a combination of chlorides of the alkaline earths, and iodine, bromine, strontium, or arsenic, besides ions of the same metals. There is convincing evidence of the value of these waters. They are primarily of value in assisting the digestion of albumin and starch, by favouring a free secretion of the digestive juices, restoring the mucosa to a healthy condition, and removing functional disorders of the liver. They have been known to increase the output of uric acid 25 or 30 per cent. There are objections to chloride waters, based on the failure of the kidneys, in many gouty persons, to excrete salt, and for this reason the salt-containing waters of Kissingen, Homburg, Wiesbaden, and other places are said to be theoretically unsuitable; but clinical experience has shown them to be of great value. The strongest saline waters of Harrogate are very beneficial for chronic gout, if due precaution is first taken to procure a thorough action of the bowels.

The sulphurous waters of Harrogate in England, Pitkeathly and Strathpeffer in Scotland, Eaux-Bonnes, Luchon, Aix-les-Baines, Barège, Cauterets, Aix-la-Chapelle, and Bagnères on the Continent, are renowned for their beneficial influence over gout, rheumatic gout, and allied diseases. They favourably influence the alimentary canal, the liver and kidneys; they relieve portal congestion, and stimulate hepatic metabolism, and increase the transformation of nitrogenous materials to urea, whereby there is a reduction in the excretion of uric acid in the urine, and relief of the gouty symptoms. When combined with douche-massage and baths, as carried out at Harrogate, Droitwich, Buxton, Woodhall Spa, Strathpeffer, Salsa-maggiore, Contrexéville, and other places, the consumption of mineral waters is decidedly beneficial.

Rheumatic Gout (Rheumatoid Arthritis).

The nomenclature of arthritis is undergoing a change, which will not be complete until the pathogeny is more clearly known. In the early part of last century all chronic joint affections were called "chronic arthritis." Garrod the elder first clearly distinguished gout from other joint affections.

Chronic arthritis has been subdivided by Hoffa and Wohlenberg into the following groups:

1. Secondary chronic rheumatism of the joints—*i.e.*, chronic inflammation and deformity left by acute rheumatism.
2. Chronic progressive polyarthritis, usually symmetrical, beginning in the small joints of the fingers and toes, characterized by an exudation and overgrowth of the capsule.
3. Arthritis deformans, either monarticular or oligarticular, due to old age and trauma.
4. Ankylosing fixation of the spinal column.
5. Heberden's nodes or large nodular growths localized in the terminal phalangeal joints.

His, basing his opinion on clinical experience, considers gout stands in a certain relationship to chronic arthritis, and that both diseases are founded on a general diathesis, or latent morbid disposition of the tissues to disease. The following factors are recognized by His in the production of chronic arthritis:

1. Trauma, old hæmorrhages, inflammation, tuberculosis, and osteomyelitis; these causes lead to mono-arthritis.
2. Acute inflammation, leading to so-called secondary arthritis.
3. Infectious diseases: scarlet fever, erysipelas, and other forms of sepsis, more frequently gonorrhœa, syphilis, and tuberculosis.
4. Bacterial invasion, which he considers is not yet proved.
5. Defective metabolism: metabolic osteo-arthritis.

The dietetic **treatment** should tend to establish a better metabolism. In rheumatoid arthritis the amount of food should not be restricted Instead of the low protein diet recommended for gout, a full and nourishing diet is required to improve the general condition and strength of the patient. Without voluntarily choosing foods which contain the greatest amount of purins, there is little doubt that the stimulating effect of animal food is beneficial. A low diet does harm. Meat, fish, fowl, and eggs must not be restricted. Armstrong of Buxton[1] says: "Order generous diet, always bearing in mind the associated gout and rheumatism, and with a leaning towards butcher's meat and the exclusion of carbohydrates." Garrod gives similar advice. Luff[2] says: "The diet should be as nutritious and liberal as the patient can digest. Animal food should be taken freely, but not to the exclusion of vegetables."

The patient may consume most kinds of food. But care must be taken to avoid or prevent indigestion, catarrh of the alimentary canal, or disturbance of the liver. A daily evacuation of the bowels is necessary. The dietary for auto-intoxication is necessary in some cases, but the restriction of carbohydrates is equally essential

[1] *Brit. Med. Jour.*, 1901, ii. 1036. [2] *Ibid.*, 1907, ii. 1043.

when there is any fermentation. The consumption of fat is useful by aiding general nutrition and phagocytosis. Cod-liver oil, cream, butter, bone-marrow, and commercial preparations, such as Virol, are very beneficial. The use of alcohol may be encouraged in a moderate degree, especially red wine—*e.g.*, good Burgundy, Volnay, or other kinds which agree. The sour-milk treatment is good for some cases. A dietary such as the following would be appropriate:

Breakfast.—Bacon and one egg, *or* fish, *or* slice of cold fat ham and tongue. Stale bread, rusks, or dry toast, and butter. Tea or coffee, with little sugar, but plenty of cream. Avoid jam, marmalade, and stewed fruit.

11 *a.m.*—Half a pint of kephir, koumiss, or other soured milk.

Midday Meal.—Fish, meat, poultry, or game; with cabbage, cauliflower, spinach, turnip-tops, kidney beans, boiled onion, or celery. Custard, junket, jelly, stewed fruit (sweetened with saccharin), and cream. One or two glasses of wine. Half a pint of kephir, koumiss, or soured milk.

5 *p.m.*—Tea with cream (*no sugar*), rusk, toast, zwiebach and butter.

Evening Meal, 8 *p.m.*—Oatmeal porridge or gruel, milk and cream; dry toast or rusk, butter. A glass of kephir or koumiss at bedtime.

The patient should avoid potatoes, turnips, carrots, swedes, and other roots or tubers, also milk puddings, pastry, suet puddings, Yorkshire puddings, etc., until there is an entire freedom from intestinal derangement and alimentary toxæmia. After this, the evening meal may be improved by the substitution of meat, fowl, fish, or cold fat ham for gruel; and a little soup may be taken at the midday meal.

Passive movements, massage, and douche-massage, electric light, radiant heat, and Bier's hyperæmic method have a proper place in the treatment. Fresh air is an important element, and change of climate is beneficial. The disease requires a combination of warmth, low humidity, and equability of temperature, which is scarcely possible in England. Egypt, Grand Canary, and Bermuda are good winter resorts; but Cheltenham is sheltered from the east winds, and is very suitable for cases which cannot be sent abroad.

Chronic Rheumatism (Fibrositis).

The effect of cold and damp on people with a gouty tendency is to cause pain in various muscles and nerves, their fibrous sheaths, the sheaths of tendons, the membranous tissues of joints and periosteum of bones. This is due to fibrositis. The group includes lumbago, stiff neck, sciatica, neuralgia, neuritis, painful joints, and other conditions. It arises from bacteria of various kinds which get into the system through decayed teeth, the mucous membranes of the nose, pharynx, stomach, vagina, uterus, and other surfaces. Any discoverable septic trouble should be cured.

In the treatment of these cases the food need not vary very much from the normal. The quantity should be moderate, enough to meet the needs of the body, and a little more to encourage "good condition," without undue fatness. It should be light and diges-

tible. A moderate amount of animal food should be taken. Two meals a day may consist of meat, fish, fowl, eggs, bacon, ham, oysters, tongue, plainly cooked, and consumed without rich sauces, forcemeat, or condiments. Custards, junkets, jellies, milk puddings, and other light puddings may be taken. Potatoes, fresh vegetables, and raw fruit are useful for their mineral salts and organic acids.

Care should be taken to avoid indigestion, catarrh of the alimentary canal, liver complaint, and auto-intoxication. (See the articles under these headings.) Carbohydrates of all kinds should be taken in great moderation, especially sugar, jam, marmalade, sweet puddings, cakes, etc.; if they have been habitually taken to excess, cut them out. Butter, cream, and other fats may be taken abundantly. Tea and coffee should be limited to one cupful twice a day, and taken without sugar; but plain water, hot or cold, may be taken abundantly. The majority of rheumatic persons are better without any alcohol; but if any is considered necessary, it may consist of dry cider, Moselle, hock, or whisky. Beer, stout, and other malt liquors should be forbidden.

Catarrh of the alimentary canal, genito-urinary organs, or other mucous membranes, must be cured. Such catarrh is favoured by (1) excess of proteins; (2) excess of sugar and other sweets; (3) excess of cooked fruits. If meat has been habitually taken to excess, prescribe a lacto-vegetarian diet for a month or two.

A warm dry climate is preferable to sea or lowland air, and is suitable for a winter resort. A high, dry, bracing or stimulating residence is better than residence in a soft, humid atmosphere. Spa treatment is excellent for many cases. The sulphurous water of Harrogate Old Spring is reputed to be curative. Other sulphurous waters and brine waters are beneficial. Bathing, douche-massage, hot air, radiant heat, and cataphoresis are useful helps in treatment.

CHAPTER XIV

OBESITY

THE deposition of fat in the body is commonly due to superalimentation or the consumption of food in excess of the requirements of the body. This is aided by insufficient exercise, diminished metabolism, or nutritional disturbance of glandular and trophic origin. Three types of obesity are recognized:

1. **Simple obesity,** occurring in persons with high colour and good circulation. They are plethoric, eat and drink more than they need, possibly have a little glycosuria and arthritism. It yields readily to treatment.

2. **Anæmic obesity,** occurring in pale, flabby persons, who do not eat too much, perhaps not enough. They are incapable of much exertion, and their circulation is probably defective. It may be a sequel of the former, owing to failure of the circulation, renal, or other disease. It is less easily cured. A subtype consists of those with hydræmic plethora; their tissues become waterlogged, owing to increase in the failure of circulation.

3. **Pathological obesity,** arising from changes in the pituitary, thyroid, adrenal, or other glandular organs.

Obesity may also be classified as **exogenous** and **endogenous**, the former arising from a disproportion between the food consumed and the output of heat and energy, the latter from a normal consumption of food, but defective metabolism. Heredity plays an important part in many cases, obesity runs in families, the same as grey or brown eyes, tall or short stature, hairiness or baldness, and other family characteristics. The tendency to obesity runs through many generations, and many people who possess this quality become fat quite early in life. On the other hand, the family disposition may be to a thin, spare body. These people never fatten, even when they eat and drink in excess. A placid disposition tends to obesity; a nervous and restless disposition to the opposite condition. Age also influences the condition. In infancy there is a natural tendency to plumpness, when the supply of food is good, and it may arise from an excess of carbohydrates. In youth, a moderate degree of fatness is beneficial, especially at puberty, when physiological changes are in progress. From ten to fifteen years of age girls are fatter than boys; at a later period the reverse obtains. Undue

fatness at this period is favoured by an hereditary tendency to obesity, diabetes, and arthritism. During early adult life, the human body and metabolism are very active, and the consumption of food or potential energy is counterbalanced by a corresponding display of kinetic energy in the form of work or play. After thirty or forty years of age, the individual becomes less active; athletic sports are dropped, less walking exercise is taken, and the occupation is probably of a more sedentary character. At this period the consumption of potential energy (food) exceeds the display of kinetic energy—in other words, the food consumed exceeds the amount used; it is stored as fat. At a later period the circulation or the kidneys may become defective, and the retention of water and chlorides in the organism, hydræmic plethora, adds to the bulk of the body.

The nutrition of the body is regulated by the internal secretions of the glands. The influence of the genital organs on nutrition is shown by the effects of their removal from birds, oxen, women, and men. Obesity occurs in children when the development of the genital organs is delayed, and it diminishes when the reproductive functions are established. Lesions of the pituitary body cause an increase of adipose tissue in the body; removal of a tumour from this body or administration of pituitary extract is followed by a reduction of adipose tissue. Obesity becomes manifest when the thyroid gland is deficient in activity, and the opposite condition obtains when it is abnormally active. Many errors of nutrition are associated with glandular lesions, and various authorities consider obesity is a disturbance of metabolism, allied to diabetes and gout, in which the power of utilizing sugar is defective, while that of synthetizing fat remains normal.

The normal diet has been much discussed in other parts of this work. According to Voit's standard, a man weighing 154 pounds (70 kilos) requires 119 grammes of protein, or 1·7 grammes per kilo, and enough food to supply 32 calories per kilo for a sedentary occupation, 35 to 48 calories per kilo for ordinary muscular work, and as much as 68 calories per kilo per diem when doing extraordinarily severe work. These calculations were confirmed by Atwater. Now, if a man of sedentary occupation consumes as much food as a labourer, it is to be expected that the body will store some of it in the form of fat. If the food is normal, and the metabolism less than normal, it is also likely that the body will put on weight. The consequence is fatty infiltration of the tissues, and possibly of various organs. It is an easy matter to step over the boundary-line dividing sufficiency from excess; thus, 150 calories would be derived from any of the following: 2 ounces of bread, $\frac{3}{4}$ ounce of butter, $1\frac{1}{2}$ ounces of roast mutton, $1\frac{1}{8}$ ounce Cheddar cheese, 6 ounces of milk, or $1\frac{1}{4}$ ounces of sugar. The storage of 150 calories of energy day by day, in the form of fat, would soon lead to obesity or corpulence.

Fat is derived in the body from an excess of protein, fat, or carbohydrate, when the total consumption exceeds the expenditure. The following equations will show the mode of transformation :[1]

1. $\underset{\text{Dextrose.}}{14C_6H_{12}O_6} = \underset{\text{Tri-stearin.}}{C_{57}H_{110}O_6} + \underset{\text{Glycerose.}}{C_3H_6O_3} + 24CO_2 + 26H_2O.$

2. $\underset{\text{Dextrose.}}{13C_6H_{12}O_6} = \underset{\text{Oleo-palmitin-stearin.}}{C_{65}H_{104}O_6} + 23CO_2 + 26H_2O.$

3. $\underset{\text{Albumin.}}{C_{72}H_{112}N_{18}O_{22}S} + 14H_2O = \underset{\text{Urea.}}{9N_2H_4CO} + \underset{\text{Tri-palmitin.}}{C_{51}H_{98}O_6} + \underset{\text{Glycerose.}}{C_3H_6O_3} + 9CO_2 + S.$

4. $\underset{\text{Albumin.}}{C_{72}H_{112}N_{18}O_{22}S} + 139O_2 = \underset{\text{Tri-stearin.}}{2C_{57}H_{110}O_6} + \underset{\text{Urea.}}{36N_2H_4CO} + 138CO_2 + 42H_2O + S.$

5. $\underset{\text{Tri-stearin.}}{2C_{57}H_{110}O_6} + 67O_2 = \underset{\text{Dextrose.}}{16C_6H_{12}O_6} + 18CO_2 + 14H_2O.$

The ultimate destination of fat is to supply the body with heat and energy by oxidation. According to Chaveau, Gautier, and Hanriot, it must be transformed into carbohydrate before it reaches its final stages of oxidation, and for this reason carbohydrates are more readily oxidized in the tissues than fat, and when the supply of carbohydrate is sufficient for the needs of the body, fat is not used. It is probable, therefore, that in many cases of obesity, or tendency thereto, the fat and fat derived from protein of the food is not used at all, but stored up owing to the deficiency of oxidation.

Many persons who consume more than the normal amount of food never become fat; indeed, there are many who never reach the normal weight. There are several explanations. The first is an abnormal oxidation and activity of the thyroid gland; the second is derived from a consideration of the cutaneous area. A small body has a proportionately larger area than a large one, and a wrinkled body or angular person than a person with a smooth, rounded contour. The increase of surface in proportion to the weight of the body leads to a greater radiation of heat; in other words, a thin person loses more heat than a fat one in proportion to size and weight, and this leads to a greater expenditure of energy. Again, a healthy person may remain thin because the absorption of food is abnormally low. This may arise from a peculiarity or idiosyncrasy against one class of food; it may be the fat, protein, or carbohydrate, is not absorbed. In other cases the proteins and carbohydrates are destroyed in the bowels by organisms, or there is a general failure of absorption owing to catarrh of the mucous membrane.

Obesity is sometimes due to defective metabolism in the tissues. The only condition in which the consumption of oxygen and excretion of CO_2 are decidedly decreased is obesity. This may arise from deficiency of the intracellular enzymes or some substance which activates them. There is evidence to show that this explains why one person uses all the food he consumes and another stores it as fat. But there are other points to be considered. The heat radiated from a rotund body is less than from an angular body, and therefore the heat lost by a stout person is less than normal. Moreover, the layer of subcutaneous fat (*panniculus adiposus*)

[1] Equations 1 and 3 by Gautier, 2 by Hanriot, 4 and 5 by Chaveau.

is a bad conductor ; it becomes gradually thicker, and is a conservator of heat. Fat is an inert tissue; it does not undergo active metabolism, and does not need nourishing like the active tissues of muscles, nerves, and glands.

TREATMENT.—The indications are—(1) To remove any discoverable cause of retarded metabolism or curable disorder of the glands; (2) to harmonize the consumption of food and drink with the output —*i.e.*, with the excretion of nitrogen and expenditure of energy; (3) to remove the ill-effects arising from the deposition of fat in the tissues and upon or within the organs of the body. There are various modes of meeting these indications; but the treatment of obesity generally resolves itself into the limitation of the diet, exclusion of alcohol, ordering light clothing, the use of cold baths, and plenty of physical exercise. It can be shown that exercise alone will not cure the majority of cases of obesity. The patient must be dieted. But it is advisable to ascertain that the kidneys are in good working order and the heart not dangerously affected before putting the patient on a rigid carbohydrate-free diet. The urine should be examined for albumin and sugar. The excretion of nitrogen by the kidneys should be at least 90 per cent. of that consumed; and it should consist of 85 per cent. of urea and 15 per cent. of other nitrogenous bodies. The patient's family history and his own past history should be inquired into, especially with regard to food, drink, work, exercise, and sleep; each point may present some indication for modification of the treatment. The principal dietaries in use will be now considered; but no diet ever devised is capable of universal application.

1. **The Salisbury or Carbohydrate-free Diet.**—It has been described elsewhere. It consists of 3 pounds of lean beef and 5 or 6 pints of hot water daily, providing from 1,800 to 2,400 calories of energy. The difference in calorie value is due to variation in the amount of fat interspersed between the muscular fibres of the meat. The consumption of a large amount of meat has been thought to induce the oxidation of fat in the body; but that is not a proper explanation. It was determined by Parkes, and confirmed by Atwater and many others, that an adult body requires about 300 grammes (10½ ounces) of carbon a day to supply it with heat. The amount of lean meat required to supply this quantity of carbon would be 6½ pounds, an enormous quantity. Therefore a diet of 3 pounds of lean meat is of low value; it only contains 140 grammes of carbon, and yields 2,000 calories; and the tissues of the body, usually the fat, are consumed to make good the deficiency. There are many people who perforce must live on animal food for months together; they get thin, and their muscles usually become hard and wiry. The thin and spare American who consumes much animal and little vegetable food is often held up as an example of the excessive consumption of proteins.

Modified Salisbury Diet.—I have for many years prescribed Towers-Smith's modification of the above diet for cases where

the obesity is due chiefly to excessive consumption of food. It is very effective in producing a rapid reduction of weight in robust and plethoric persons. The treatment is divided into three stages:

First Stage: Fourteen Days.—The diet consists of 3 pounds of lean beef-steak, 1 pound of codfish, and 6 pints of hot water daily. These are divided into four meals. The meat may be minced, grilled, roasted, boiled, or steamed, or made into cakes; the fish should be steamed or boiled. The only accompaniments allowed are mustard, pepper, chutney sauce, and a very little salt or vinegar. No bread, toast, biscuit, vegetables, or other articles, should be allowed at this stage.

Minced meat is prepared by cutting the steak into strips, removing skin fat, connective tissue, and putting it twice through a mincer. The pulp is then put into a large saucepan, with pepper, salt, and a little water, or stock, free from fat, and beaten until it is like a purée. It is then put over a slow fire, and stirred constantly until it is cooked through; this occupies fifteen or twenty minutes. It should now be free from lumps or hard bits. It is served in a bowl and eaten with a spoon.

Beef-cakes are prepared by forming the seasoned pulp into flat cakes, about ½ inch thick, and grilling them over a quick fire. They require to be turned once a minute until they are broiled; the time required is about five minutes. They should be light, not hard, nor overcooked.

The water should be taken at an agreeable temperature. One pint should be taken at 6 or 7 a.m.; the second pint half an hour before breakfast; the third half an hour before the midday meal; the fourth before the afternoon meal; the fifth before the evening meal; and the sixth at bedtime. If it is desired, the water may be flavoured with a little salt, clear tea, or lemon-juice. It is unnecessary to flavour it, because hot water is soon tolerated and relished by the patient. The necessity for a great quantity of water to wash out the débris from the body is accentuated by the fact that 3 pounds of meat contains 286 grammes of protein, or 43 grammes of nitrogen, which is three times as much as the body usually obtains, and six times as much as the physiological minimum.

Second Stage: Twenty-one Days.—In this period the amount of hot water is reduced to 4 pints a day, and the food is varied. The total consumption of meat and fish is only 3 pounds a day. It may consist of any kind of meat free from fat (except pork); any kind of game, rabbit, or fowl; fish such as halibut, haddock, cod, turbot, skate, plaice, sole, or whiting. The patient may have 2 or 3 ounces of bread in the form of dry toast, stale bottom crust, captain's biscuits, unsweetened rusk, gluten bread, or kallari biscuit. A small amount of green vegetables, such as cabbage, savoy, Brussels sprouts, cauliflower, turnips, or spinach, may be eaten; and raw salad, such as lettuce, endive, celery, tomato, watercress, cucumber or radishes. The condiments are as before.

Third Stage: Twenty-one Days.—The hot water is reduced to 3 pints a day. The diet should be composed largely of the animal foods detailed for the second stage; it should be in the proportion

of two-thirds animal and one-third vegetable food. It may consist of any meat, fish, or fowl, as free as possible from fat; any vegetables free from sugar; dry toast, bottom crust, rusk, hard biscuit, kallari biscuits; and fruits, such as apples, which do not contain much sugar or starch. The patient may have a cupful of tea sweetened with saccharin, dulcin, or saxin, twice a day; and, if it is desired, a little cider, hock, Moselle, Volnay, Beaune, or other wine free from sugar, and diluted with soda, seltzer, Perrier, or Apollinaris water.

Under this treatment the weight falls 2 to 3 stones in three months. It is useless to undertake it unless it is rigidly carried out. The patient should be impressed with the fact that there is no real hardship after the first stage of treatment—fourteen days. No person suffering from any organic disease ought to be put through this course. It should also be observed that it is quite possible for the diet to be followed by peculiar and serious consequences. These may be of a mental or cerebral type. Lazarus-Barlow[1] says the close dependence of maniacal attacks on the administration of a protein diet strongly suggests that the symptoms are due to the absence of those metabolic changes occurring in the transformation of albumin into urea which normally occur in the liver. Ebstein regards obesity as due to the fact that obese persons have less power of combustion than other people; their metabolism is slow and delayed. Either from delayed metabolism, insufficiency of water to wash out débris, or some other cause, maniacal excitement does occasionally occur during this treatment. But it never occurs if the treatment is carried out properly and due care is taken to avoid prescribing it for persons having an organic disease.

2. **The Banting Diet.**—This diet was recommended by Dr. Harvey for an obese person named Banting, who published it in a Letter to the Corpulent. It is interesting from being one of the earliest dietaries formulated for this complaint. It consists of 13 to 16 ounces of animal food, free from fat—divided into three meals; 3 ounces of bread, rusk, or biscuit; 6 to 12 ounces of fresh vegetables and fruit; and not more than 2 pints of liquids. The meals are—

Breakfast.—Four or five ounces of lean beef, kidneys, mutton, or fish; 1 ounce of dry toast or biscuit; a large cup of tea without sugar or cream.

Midday.—Five to seven ounces of lean meat (any kind except pork), game, poultry, or fish (any kind except salmon, eel, or herring); any vegetables except potato, parsnip, carrot, or beetroot; cooked fruit without sugar or cream; dry toast, 1 ounce; claret, sherry, or Madeira wine, two wineglassfuls.

5 or 6 p.m.—A large cup of tea without sugar or cream; a strip of dry toast or rusk; raw or cooked fruit, 2 or 3 ounces.

Evening Meal.—Three or four ounces of lean meat, fish, or game; green vegetables; a glass or two of wine.

Bedtime.—A glass of spirit and water, without sugar; or a wineglassful of wine well diluted with water.

To be Avoided.—Pork, veal, eels, salmon, herrings, the vegetables named above, champagne, port, stout, porter, ale, and beer.

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[1] "Textbook of Pathology," p. 654.

The entire dietary contains 170 to 180 grammes of protein, 7 to 10 grammes of fat, 70 to 80 grammes of carbohydrate, and yields at most 1,160 calories of energy. The energy is below the expenditure of a man at rest, and the body must be drawn upon for the balance. The wine is unnecessary, and may be replaced by a little more vegetable food.

3. **Mixed Diets.**—The Banting diet is a good example of mixed feeding for the reduction of obesity. One and all, mixed diets are examples of low feeding—*i.e.*, the value of the food is reduced to 1,100, 1,200, or 1,500 calories, according to the kind of case and the rapidity of reduction desired. The table on pp. 460, 461 gives dietaries recommended by prominent physicians. They vary owing to differences in the opinions of the prescribers and the effect to be produced. Richter allows potato, but no bread. Ebstein regards obesity as due to deficient combustion, or slow and delayed metabolism, of carbohydrates and fat. He prescribes fat in his diet on the assumption that it lessens appetite, produces a feeling of satiety, and lessens thirst. This would be wrong, except when there is a tendency to glycosuria, because fat is more difficult of oxidation than carbohydrate. His diet includes about 3 pints of liquid, including two large cups of tea, which enable the patient to bear, without exhaustion, the reduction of food. Hirschfield's diet is similar, but he allows more carbohydrate; he recommends the food should contain—*Minimum*: protein 100, fat 41, carbohydrate 50, grammes; calories, 1,000. *Maximum*: protein 140, fat 65, carbohydrate 167, grammes; calories, 1,400. Oertel reduces the amount of fluids consumed. Although water is not fattening, it is an undoubted fact that the continual excessive consumption of liquids increases the weight of the body. The observations of Ter-Gregorianz and Karchagin[1] support this experience: when large quantities of water are consumed, the subjects increase in weight, assimilation is slightly decreased, but metabolism is increased; when the quantity of water consumed is less than normal, the weight of the body diminishes, but assimilation is improved, and the metabolism slightly diminished. Therefore, a limitation of the intake of fluids in cases of obesity is a correct procedure. Oertel's treatment includes 1½ pint of liquids daily; at the same time he recommended a large consumption of meat, and this is the weak point in his treatment; a marked increase in the consumption of protein is not borne well if the intake of liquids is limited. Schweninger prescribes a similar diet to Oertel; but he forbids any liquid to be taken with the meals. This is an important rule in feeding the obese: the person eats less when no liquid is taken with the food. Oertel's and Schweninger's dietaries are suitable for anæmic obesity and hydræmic plethora. Germain Sée[2] pointed out, however, that the restriction of fluids would be very injurious to

[1] *Cf.* "Digest of Metabolism Experiments," Bulletin 45. U.S. Department of Agriculture.

[2] "Du Régime Alimentaire."

gouty persons and those with uric acid deposits; but he strictly forbids this class of obese persons to take alcohol, because of its well-known tendency to favour fatty degeneration. Von Noorden[1] considers that, as the heart is usually weakened in obese persons, the intake of fluids should not be reduced below 2½ pints. Von Noorden's treatment of obesity consists in a limitation of the calorific value of the food rather than restriction of liquid (see table). He recommends small and frequent meals, containing a minimum or maximum, according to the effects desired. Richter also prescribes small and frequent meals. Boas[2] does not agree with restriction of fluids; and he considers it is essential that the proteins should not be reduced below 90 grammes daily, while the non-nitrogenous foods should be much reduced; but he thinks it is immaterial whether fat or carbohydrate is most reduced.

4. **Dry Diet.**—The Oertel-Schweninger diet is denominated a "dry diet" when the total fluids are cut down to 15 or 25 ounces daily. The liquids may consist of a small cup of tea or coffee at breakfast and tea-time, and a similar amount of water, wine and water, or spirit and water, after the midday and evening meals. It is especially useful in some cases complicated by fatty degeneration of the heart, dyspnœa, palpitation, etc.; and for those who habitually drink too much. Groco[3] says: "It is doing good if the elimination of urine remains unchecked; but if the urine becomes scanty, the perspiration diminished, or the digestion disturbed, it is doing harm, and should be stopped." It sometimes causes gastro-intestinal disturbances, gout, renal colic, and neurasthenia. The restriction of fluid is an empirical measure; there is no satisfactory explanation of the reduction of fat. The reduction of weight is largely due to removal of water from the tissues or reduction of hydræmic plethora. The reduction of fat is mainly due to the low calorie value of the diet; water is produced in the tissues by the oxidation of fat. The fluid foods should be reduced gradually. No dietary can be framed which is universally applicable, but the following is a useful example:

Dry Diet for Obesity.

8 *a.m.*—Mutton or veal, 6 ounces; *or* fish; *or* two eggs; bread, 3 ounces; *no butter.*

9.30 *a.m.*—A small cup of tea or coffee; little milk; no sugar.

11 *a.m.*—A sandwich of bread and lean meat.

1 *p.m.*—Meat, fowl, game, or fish, 6 or 8 ounces; boiled vegetables; *or* salad; cheese and a biscuit; fresh fruit, 2 or 3 ounces. *No soup, potatoes, bread, or sweets.* Two glasses of hock, Moselle, or Chablis; or brandy or whisky, 1 ounce, with water, ¼ pint.

4.30 *p.m.*—A small cup of tea; little cream, no sugar.

6 *p.m.*—Cold meat, fowl, or tongue, 5 or 6 ounces; *or* two boiled eggs; boiled vegetables or salad. A glass of wine.

10 *p.m.*—Two glasses of wine, or 1 ounce of spirit in 5 ounces of water.

[1] "Disorders of Metabolism," part iv.
[2] *Archiv f. Verd.-Krankheiten*, 1908, xiv. 210.
[3] *Riv. Crit. di Clin. Med.*, February 27, 1904.

Ebstein.

6.30 to 7.30 a.m.

Bread, 2 oz. (may be toasted).
Butter, plenty.
Tea, large cup at end of meal; *no sugar.*

2 p.m.

Clear bone soup.
Cooked meat, 5 or 6 oz.
Cabbage, spinach, peas, or string beans, *ad lib.*
Raw fruit or salad.
Cheese, small piece.
Cup of tea.
Or 2 glasses of wine.

5 p.m.

Cup of tea.
Rusk, biscuit, or bread-and-butter.

7 p.m.

Fat meat, ham, or fish, 3 or 4 oz.
Or 1 egg.
Bread-and-butter, 1 oz.
Vegetables.
Salad.
Fresh fruit.

Protein ..	.. 100 grammes.
Fat ..	.. 85 ,,
Carbohydrate ..	50 ,,
Energy ..	.. 1,400 calories.

Hirschfield.

8 a.m.

Bread, 2 oz.
Butter.
Coffee, 1 cup; *no sugar.*

11 a.m.

2 boiled eggs.
Bread, 1 oz.

1.30 p.m.

Soup, 4 oz.
Boiled rice, 2 oz.
Lean meat, 8 oz.; *no fat.*

5 p.m.

Black coffee.

7 or 8 p.m.

Bread, 4 oz.
Cheese, 2 oz.
Butter, ½ oz.

Protein	80 grammes.
Fat ..	70 ,,
Carbohydrate	160 ,,
Energy	1,636 calories.

Oertel.

	Min.	Max.
8 a.m.		
Coffee ..	5 oz. ..	—
Milk	1 oz. ..	—
2 eggs,		
Or lean meat	4 oz. ..	6-8 oz.
Bread ..	1 oz. ..	2-3 oz.
Butter ..	— ..	⅓ oz.
11 a.m.		
Cold lean meat or ham ..	2 oz. ..	—
Rye bread ..	2 oz. ..	—
Glass of wine.		
1.30 p.m.		
Clear soup ..	4 oz. ..	—
Wine	— ..	7½ oz.
Fat meat ..	6 oz. ..	7-8 oz.
Vegetables ..	2 oz. ..	—
Salad	1 oz. ..	2 oz.
Rye bread ..	¾ oz. ..	—
Roll ..	— ..	1 oz.
Milk pudding	— ..	3½ oz.
Or fresh fruit	3½ oz. ..	3½ oz.
4.30 p.m.		
Coffee ..	5 oz. ..	—
Milk	¾ oz. ..	6 oz.
8 p.m.		
Caviar ..	— ..	⅓ oz.
Lean meat, fowl, or game,	6 oz. ..	7 or 8
Or 2 boiled eggs.		
Salad ..	1 oz. ..	—
Rye bread ..	¾ oz. ..	—
Cheese ..	½ oz. ..	—
Fruit	3½ oz. ..	—
Wine	— ..	7½ oz.

Protein ..	150-170 gramm[es]
Fat	25- 50 ,,
Carbohydrate	80-120 ,,
Energy ..	1,200-1,650 calori[es]

Schweninger.	Von Noorden.	Richter.	Robin.
8 *a.m.* ea or coffee, 8 oz. Iilk, 1 oz. read or toast, 3½ oz. 1.30 *p.m.* lear soup, 3 or 4 oz. Ieat, game, poultry, or fish, 7 or 8 oz. read, 1 oz. egetables or salad, 6 or 7 oz. *r* wine, 6 or 7 oz. 5 *p.m.* ea, a cupful. read, 1 oz. 7 *or* 8 *p.m.* oiled eggs, 1 or 2. read, 1 oz. heese, 1 oz. alad or fresh fruit, 6 or 7 oz. *r* wine, 6 or 7 oz.	8 *a.m.* Tea or coffee; *no sugar or milk.* Meat, ham, fowl, or game, 3 oz. Bread (no butter), 1 oz. 10 *a.m.* 1 egg, hard boiled. Salad. 12 *noon.* Clear soup, 5 oz. 1.30 *p.m.* Clear soup, 5 oz. 2 *p.m.* Lean meat, fowl, or fish, 5 or 6 oz. Vegetables. Fresh fruit, 3 or 4 oz. 3 *p.m.* Black coffee, 1 cupful. 4 *p.m.* Fresh fruit, 7 or 8 oz. 6 *p.m.* Skim milk, 10 oz. 8 *p.m.* Cold lean meat, ham, tongue, fowl, or game, 4 or 5 oz. Pickles. Bread, 1 oz. Cooked fruit, 3 or 4 oz.	8 *a.m.* Coffee or tea; *no sugar.* Ham, 2 oz. 1 roll. 10 *a.m.* 2 boiled eggs. 12 *noon.* Fresh fruit, 3 or 4 oz. 1.30 *p.m.* Lemonade, 10-15 oz. *no sugar.* 2 *p.m.* Clear soup, 5 oz. Lean meat, 3-4½ oz. Potatoes, 5-7½ oz. Vegetables, 3½ oz. *Or* salad, 3½ oz.; *no sauce.* 4 *p.m.* Coffee, a cupful. 6 *p.m.* Fresh fruit. *Or* clear soup, 5 oz. 8 *p.m.* Lemonade, 7-15 oz. Lean meat, 3½ oz. Potato, 3½ oz. *Or* salad.	8 *a.m.* Tea; *no sugar.* Cold meat, ham, or fowl, 3 or 4 oz. Bread (*crumb*), 1 oz. 10.30 *a.m.* 2 boiled eggs. Bread, 1 slice. Butter. Cup of hot tea. 1.30 *p.m.* Meat, ham, fowl, or fish, 5½ oz. Salad, with lemon-juice, a large plateful. Fresh fruit, *ad lib.* 5 *p.m.* Tea, a cupful. Bread. Butter. 7.30 *p.m.* Same as at 1.30. *Total.* Meat, etc., 18 oz. Bread, 3 or 4 oz. Butter, ¾ oz. Fruit and vegetables, 16 oz.
	Protein 120-180 grms. Fat 30-50 ,, Carbohydrates, 100-120 ,, Energy 1,182 - 1,510 calories.		Protein 156 grammes. Energy 1,470 calories.

5. **The Milk Cure.**—This is applicable to many cases of abdominal plethora, with cardiac weakness or renal inadequacy. One pint of milk contains 21 grammes of protein and 410 calories of energy. Breakfast should consist of 1 pint of milk only; lunch may consist of 6 ounces of lean meat, a plateful of boiled vegetables (no bread or potatoes), and ½ pint of junket; tea, ½ pint of junket and two cups of tea, little sugar; and dinner of 1 pint of milk and two apples. The patients seldom complain of hunger or thirst. I have reduced the weight of many people with such diet. It contains enough protein, while the fat and carbohydrate is diminished, and the heat value is about 1,800 calories. If the midday meal consists only of 1 pint of milk or junket, the total calorie value will be 1,305 calories. The milk may be boiled, taken plain, hot or cold, in the form of junket or soured milk. Karrel, Moritz, Lenhartz, Roemheld, and others have obtained excellent results from its use. Moritz recommends the milk to be taken ½ pint every three hours; but this mode is inconvenient for people who desire to follow their occupation, and is applicable only to those who are more or less confined to the house.

"**Milk days**" were instituted by Roemheld; he recommends about 2 pints of milk, preferably skim milk, to be taken twice a week, and nothing else. On the other days he allows sufficient ordinary food to supply 16 to 24 calories per kilo (8 to 11 calories per pound) of body-weight.

"**Miniature cures,**" lasting five to eight days, were adopted by Strauss[1] for the treatment of cases complicated by glycosuria, gout, or cardiac affections. He keeps the patient in bed during the "cure," has him massaged, and allows a tumblerful of milk four or five times a day, and on the last two days an apple or orange. In the "after-cure" he prescribes for a few days a mixed diet of meat, sausage, vegetables, milk, and a little bread; the whole yielding 1,500 or 1,600 calories. A repetition of the cure is recommended after an interval of a few weeks.

A consideration of the milk cure shows that the beneficial results are due primarily to the low calorie value of the diet; secondly, to the removal of superfluous sodium chloride, milk being practically salt-free. Strauss considers that for every gramme of sodium chloride excreted there is a corresponding excretion of 6 ounces of water.

6. **The Fruit Cure.**—A diet of fruit and nuts, when properly arranged, is sufficient to supply the needs of the body. But if it is not properly balanced, muscular tissue as well as fat will be lost. The following examples are from a well-known source:

(1) *Grapes, Olives, Olive-Oil, and Tomatoes.*—During four days observation a man consumed 21¾ pounds of grapes, 4 ounces of olives, 2 ounces of tomatoes, and ¾ ounce of olive-oil. These contained protein 55, fat 92, carbohydrates 890; energy 4,908 calories. The energy of food assimilated in four days was 4,220 calories, or

[1] *Wien. Med. Klinik.*, March 27, 1910.

1,055 calories daily, and the protein only about 14 grammes. He lost 2 pounds weight in two days. An examination showed daily income of nitrogen 3·89 grammes, daily outgo in urine and fæces 5·89 grammes; loss, 2·89 grammes, equal to ½ ounce of muscular tissue daily. In another period of four days some Brazil nuts and walnuts were added, and there was no loss of nitrogen from the body—*i.e.*, there was no destruction of muscular tissue, although there was a loss of 1 pound weight.

The grape cure is undertaken for the cure of obesity with abdominal plethora, and is worthy of recommendation if care is taken to supplement it by meat, milk, or nuts, to supply protein.

(2) *Pears, Cocoanut, and Cheese.*—During four days' metabolism experiment a man consumed 22 pounds of pears, 2 pounds of cocoanut, 2 ounces of cheese, ½ ounce of tomato, and 2½ ounces of olive-oil. He assimilated from the food—protein 106, fat 544, carbohydrates 1,326 grammes, and energy 11,875 calories; equal to 27 grammes of protein and 2,970 calories daily. There was a loss of 1½ pounds weight and about ⅓ ounce of muscular tissue.

(3) *Apples, Dates, and Peanuts.*—During four days the subject consumed 13½ pounds of apples, 2¼ pounds of dates, and 1½ pounds of peanuts. The body received daily: Protein 56, fat 68, carbohydrate 350, grammes; and 2,360 calories. The nitrogen and weight were kept in equilibrium. Without the dates and only 1 pound of peanuts the calories would be reduced to 1,600 per diem, but there would be a slight deficiency of nitrogen.

(3) *Bananas and Walnuts.*—In four days the subject consumed 14 pounds of bananas and 2½ pounds of walnuts. The daily provision was: Protein 31, fat 60, carbohydrate 182, grammes; and 1,441 calories of available energy. In this period the body lost 2½ pounds, including 3 grammes (46 grains) of muscular tissue—not a great amount.

(4) *Apples and Walnuts* resulted in a loss of 4 pounds in four days. The subject consumed 13½ pounds of apples and 1¾ pound of walnuts, making a daily provision of—Protein 34, fat 109, carbohydrate 128, grammes; and 1,400 calories of available energy. The nitrogen balance was maintained; in fact, there was a slight gain of protein.

(5) *Apples, Bananas, and Brazil Nuts.*—Loss of weight, 1 pound in four days. The total food included—Apples 13, bananas 11, Brazil nuts 2, pounds; The daily portion contained—Digestible protein 30, fat 85, carbohydrate 214, grammes; and 1,891 calories.

The above examples show that a fruitarian diet is applicable to the reduction of obesity. But care ought to be taken that the protein is not reduced below the physiological requirement. This may be done by the use of nuts. Tallien[1] strongly recommends this treatment for those who have been gross feeders and drinkers, who suffer from obesity, abdominal plethora, hæmorrhoids, gout, renal calculus, or migraine, as well as for semi-invalids who awake each morning with a headache and disagreeable taste in the mouth.

[1] *Jour. des Prat.*, May 7, 1910.

The fruit cure, he maintains, is valuable because it is a low protein diet, and supplies the system with an abundance of salts of the organic acids. He specially recommends grapes, apples, oranges, raisins, and fresh vegetables; but, he adds, "the incorrect use of a good remedy is more often responsible for bad results than the disease itself."

Summary.—(1) Ordinary obesity in persons who enjoy good health may be reduced by the Salisbury or carbohydrate-free diet; the Towers-Smith modification is better adapted for most persons, and is very safe when there is no organic disease. (2) Obesity in gouty and glycosuric persons may also be safely treated by Towers-Smith's dietary. But it should be remembered that it is not safe to cut off all carbohydrates suddenly in a marked case of glycosuria, especially when there is acetonuria. (3) In obesity with fatty heart, beer heart, other cardiac diseases, and general debility, the methods of slow reduction should be adopted. Treatment should be begun by a milk diet, preferably combined with rest in bed, and then Von Noorden's or Oertel's diet may be used. In such cases I consider it is essential to reduce the intake of fluids and forbid the use of salt. (4) In renal cases a diet containing only 70 or 80 grammes of protein is the best. Salisbury's, Towers-Smith's, Banting's, and other high protein diets would be injurious. The miniature cures of Strauss are useful. Milk diet is beneficial. Fruit cures may also be recommended. The reduction of weight should not be too rapid; 3 pounds a week is as much as ought to be allowed. In heart disease, renal affections, and other forms of ill-health, 2 pounds a week will suffice.

7. **The Diet after Reduction.**—The dietary should now be based on a reduced scale. Voit's standard of 1·7 grammes of protein and 40 calories per kilo is too high for obese persons. Many people do not utilize more than 28 or 30 calories per kilo, or 14 *calories per pound*. The animal food should not be reduced, as it contains less carbon than vegetable food; the protein should not be reduced below 1·5 grammes per kilo, or ¾ gramme per pound. The requirements should be estimated from the standard weight of the body at a corresponding age, making allowance for the increased breadth of thorax. The table by Brandeth Symonds (see p. 465) may serve as a guide to the normal weight of males at various ages.

At twenty years of age the normal weight of a man 68 inches high would be 140 pounds; at thirty it would be 154 pounds, and at forty-five about 168 pounds. It is possible at this age that his weight is 28 or 30 pounds in excess of the normal; and in a drinker it may be 50 pounds in excess. After many years' experience in treatment, I do not think it is advisable to attempt to reduce such persons to the weights given in anthropometrical tables. If a man's actual weight is 200 pounds when he ought to be only 150 pounds, I should not reduce more than half or two-thirds of the excess. Let his permanent dietary be calculated, say, on 167 pounds (76 kilos), with an allowance of 28 calories and 1·7 grammes of protein per kilo, or 2,128 calories and 129 grammes of protein. I do not con-

sider the total protein for any obese person should be permanently reduced below 100 grammes a day, nor the supply of food below 14 calories per pound. Such permanent dietary may be drawn from the following lists:

Soups.—Any kind of clear soup, except those containing vermicelli, macaroni, rice, barley, oats.

Fish.—Any kind which does not contain more than 1 or 2 per cent. of fat; sole, plaice, smelts, haddock, turbot, flounder, whiting, brill, ling, cod, hake, yellow perch, perch, pike, pickeril pike, grey pike, pollack, bream, grouper, snapper, brook trout, bass, black fish, blue fish, cusk, king fish, sturgeon, oysters, lobster, crab, etc. *Occasionally* the fatter kinds may be taken—*e.g.*, salmon, salmon trout, mackerel, eel, herring, etc.

NORMAL WEIGHT OF MALES AT VARIOUS AGES.

Height.		Age.							
		15-24 years.	25-29 years.	30-34 years.	35-39 years.	40-44 years.	45-49 years.	50-54 years.	55-59 years.
ft.	in.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
5	0	120	125	128	131	133	134	134	134
5	1	122	126	129	131	134	136	136	136
5	2	124	128	131	133	136	138	138	138
5	3	127	131	134	136	138	141	141	141
5	4	131	135	138	140	143	144	145	145
5	5	134	138	141	143	146	147	149	149
5	6	138	142	145	147	150	151	153	153
5	7	142	147	150	152	155	156	158	158
5	8	146	151	154	157	160	161	163	163
5	9	150	155	159	162	165	166	167	168
5	10	154	159	164	167	170	171	172	173
5	11	159	164	169	173	175	177	177	178
6	0	165	170	175	179	180	183	182	183
6	1	170	177	181	185	186	189	188	189
6	2	176	184	188	192	194	196	194	194
6	3	181	190	195	200	203	204	201	198

Meat.—All kinds of meat not cooked with fat, and other kinds, when divested of fat, may be consumed—*e.g.*, beef, beefsteak, leg or shoulder of mutton, veal, sweetbread, kidneys, fowl, pheasant, turkey breast, guinea-fowl, partridge, pigeon, hare, leveret, rabbit, lean ham, or tongue. Eggs and cheese may also be consumed. *To be prohibited :* Fat meat, pork, bacon, fat ham, goose, duck, and other fat food. Butter may be taken in strictest moderation.

Sauces.—The following are useful accompaniments to meat or game: Apple, onion, gooseberry, and spinach sauces; also sauce made from mint, lemon-juice, tomato, horseradish, or mushrooms.

Carbohydrates.—The allowance ought to be strictly limited. It may consist of stale bread, bottom crust, dry toast, kallari biscuit,

Caseoid bread, captain's biscuits, almond cakes, gluten bread, soya bread, etc. The total should be 4 to 6 ounces a day.

Cooked Vegetables.—Cabbage, savoy, Brussels sprouts, kale, red cabbage (saur kraut or pickle), cabbage sprouts, cauliflower, turnip-tops, seakale, cardoon, artichoke, spinach, vegetable marrow (squash), pumpkin, green peas, kidney beans (string or snap), turnips, swedes (*Ruta baga*), *new* potatoes, boiled celery, boiled lettuce, cucumber, beetroots, leeks, onions, tomatoes, mushrooms.

Salads.—Lettuce, endive, tomato, mustard and cress, white heart cabbage, onion, cucumber, watercress, garlic, etc. *Salad oil should not be used*, except a teaspoonful or two for making mayonnaise sauce.

Dessert.—All nuts, except chestnuts; all fruits, except sweet ones. Cooked fruits may have their acidity partly neutralized by the addition of bicarbonate of soda or potash, and 1 per cent. solution of saccharin can be used in place of sugar. Apples, pears, plums, damsons, gooseberries, strawberries, blackberries, and raspberries; apple-snow, *compôte* of apricots, gooseberry fool, damson cheese, raspberry cream, rhubarb mould, etc., can all be prepared in that way.

Puddings may be taken occasionally, especially those made of gluten flour, macaroni, vermicelli, almond, or cocoanut. Calves'-foot, milk jelly, and other jellies may be taken in moderation. Egg-snow, egg custard, junket, and similar preparations may be taken. No sugar or cream should be taken with them.

Beverages.—The total consumption should not exceed 2 pints a day. It may consist of plain water; tea, coffee without chicory, and cocoa made from the nibs; gaseous waters—*e.g.*, Salutaris, Puralis, Perrier, Apollinaris, soda, potash, or lithia waters; alkaline waters—*e.g.*, Vals, Vichy, Ems, Selters, Bath-sulis, Contrexéville. Fruit-juices may be taken in water and sweetened with saccharin or dulcin. A little alcohol is allowable; it may consist of dry cider, hock, Moselle, Chablis, Volnay, claret, whisky, or brandy. All alcoholic beverages must be diluted, and the amount of alcohol reckoned in the calorie value of the food. Moselle-cup, claret-cup, champagne-cup, punch, and similar diluted beverages may be allowed in moderation.

Articles Prohibited.—Excess of fat. fat meat, butter, dripping, margarine, salad oil, cream. or other fat foods. Milk pudding. cakes, pastry, boiled suet puddings, should only be taken occasionally to prevent monotony of food. Cream cheese, rich ripe cheese, should be forbidden. Also duck, pork, liver, herring, mackerel, eel, salmon, caviar, sardines, thick soups, sugar, treacle, syrup, jam, preserves, marmalade, sweet puddings, confectionery, sweet fruits (dates, prunes, figs, grapes, cherries, mulberries, dried currants, raisins, sweet apples or pears), sweet wines (port, sherry, Madeira, Marsala). Starchy foods should not be allowed *ad libitum*; for a long period it may be advisable to forbid rice, sago, tapioca, cornflour (corn starch), blanc-mange, custard made with powder; also oatmeal, maize, wheat, and other breakfast foods, dried peas

and beans. The amount of bread and potato must be strictly limited; new potatoes contain less starch than old ones; Jerusalem artichokes contain sugar, but no starch. Sweet potatoes, carrots, parsnips, asparagus, large onions, all contain much carbohydrate, and, in strict dieting, ought to be forbidden, except as an occasional variation in food.

The principles to be adopted in framing a permanent dietary are to approximate the allowance of food to physiological requirements or slightly below, and to keep the protein well up to the standard allowance. In no case must the protein be reduced below the amount required for a person of average height and weight, lest the muscles be wasted; on the other hand, everything should be done to spare the muscular tissues, to harden them if possible, and enable them to resist the emaciation which we desire to bring about elsewhere. Very much good can be done by cutting down the "extras." An ounce of sugar yields as much energy as ½ ounce of butter or meat fat, or 1¼ ounces of roast beef, or 2 ounces of bread. Four or five lumps of sugar weigh an ounce, and contain 27 grammes of assimilable carbohydrate; if this quantity is taken daily, in excess of the requirements, it might lead to an accumulation of 11 pounds of fat in the body in a year. It is therefore an absolute necessity to limit the consumption of carbohydrates, fat, and alcohol.

Physical exercise must be insisted on. It may be argued that it will increase the appetite for food. In spite of this, it is absolutely necessary to rearrange the habits. The sedentary man must take more exercise in the form of walking, golfing, tennis, bowls, rowing, swimming, or gymnastic exercises. Six or seven miles walk a day is not too much for a man of business; it should be done in sections—*e.g.*, walking to and from the office; or walking a mile six or seven times a day. Golf is an excellent mode of exercising the body. Tennis and badminton are suitable for persons under forty years of age; croquet is better for ladies over forty, and golf is still better, if there is no definite heart weakness. The Schott exercises and other simple muscular movements[1] are better for persons with heart weakness. Swimming and bathing are very efficient means of reducing or keeping the weight down. Everybody cannot bear prolonged immersion in cool water; such people may be recommended a Turkish or Russian bath once or twice a week, combined with general massage. Spa treatment is good for many patients; an annual course at Harrogate, Carlsbad, Marienbad, and similar places will reduce hydræmia and plethora, and stimulate the functions of metabolism.

[1] *Vide* "Food and Hygiene," W. Tibbles, second edition, p. 626.

CHAPTER XV

DIABETES MELLITUS

The most conspicuous signs of this disease are polyphagia, polydipsia, polyuria, and glycosuria. Blumenthal defines diabetes mellitus as the excretion of glucose in the urine due to an inability of the organism to utilize carbohydrates containing six atoms of carbon or multiples of the same. But the sugar is not always glucose (dextrose); it may be levulose, lactose, maltose, or pentose. Pentosuria is rare and usually hereditary. Levulosuria occurs in metallic poisoning. Lactosuria as well as glycosuria occurs during pregnancy, but rarely in other cases. Diabetes mellitus has been attributed to many causes; but it is impossible to put all cases down to one cause alone, and in some cases several causes contribute to the disease.

Alimentary Glycosuria may be produced in healthy persons by the consumption of 300 to 500 grammes of glucose. Pavy[1] considered the theory that sugar enters the system by osmosis or diffusion is wrong. He believed all sugar derived from food is locked up in large protein molecules, or attached as a side-chain to such molecules, and is taken up by the lymphocytes of the intestinal mucosa. According to him glycosuria results from a failure of carbohydrates to become linked to the proteins, through the absence of an amboceptor supplied by the pancreas. In alimentary glycosuria the power of carrying sugar is normal, but the consumption is excessive; in senile glycosuria this power is slightly diminished with advancing age; in diabetes mellitus the sugar-carrying power is decidedly diminished.

Hepatic Diabetes.—Claude Bérnard, who established the theory of the glycogenic function of the liver, believed diabetes mellitus was due to a disturbance of that function. This theory has met much opposition, although recent observations have shown that the liver is decidedly at fault in many cases of diabetes.

Pancreatic Diabetes.—An animal becomes glycosuric a few hours after removal of the pancreas. This organ is often diseased in diabetes mellitus. The pancreas normally supplies a ferment, which assists the liver to convert sugar to glycogen and store it in the cells. The internal secretion of the pancreas hinders the production of sugar in the liver, and the internal secretion of the suprarenal bodies increases it. When the pancreas is diseased, the

1 "Lectures on Pathology and Treatment of Diabetes Mellitus," 1909.

enzyme is deficient; hyperglycæmia and glycosuria occur as a consequence.

Suprarenal Diabetes.—The injection of adrenalin or a watery extract of suprarenal bodies into the circulation of a normal person causes hyperglycæmia and glycosuria. The suprarenal bodies constantly provide an internal secretion which influences the carbohydrate metabolism, by causing the mobilization of glycogen and its transformation to sugar. Stimulation of the chromaffin system increases this effect. In Addison's disease the secretion of adrenalin is defective, and not only is there a deficiency of sugar in the blood, but glycosuria cannot be produced artificially. In Grawitz's tumour, on the other hand, an increased secretion of adrenalin might be expected, and it is reported that glycosuria occurs in this disease, whence it is concluded that some cases of diabetes are due to adrenalinæmia.

The Thyroid and Glycosuria.—In Graves's disease, and when patients are taking thyroid extract, glycosuria may occur spontaneously; but in myxœdema and after thyroidectomy it is difficult to cause glycosuria. It is probable that some cases of diabetes are due to hyperthyroidism. It has been suggested that the pancreas supplies an amboceptor necessary to fix the glycogen in the liver and muscles, and the thyroid inhibits its production; when the thyroid is too active, the pancreas is inhibited, the glycogen is not stored, and glycosuria occurs. The **pituitary** body has a similar influence on carbohydrate metabolism, and diabetes occurs in acromegaly.

The Nervous System and Glycosuria.—The occurrence of glycosuria after puncture of the medullary floor indicates the existence of a nervous centre controlling the glycogenic function. Moreover, puncture of the medullary floor does not cause glycosuria if the splanchnic nerves have been previously cut, showing that the nervous impulses are modified by passage through the sympathetic ganglia or chromaffin system. Experiments on the nervous system give support to those physicians whose treatment of diabetes is directed towards a betterment of the nervous organization by the use of drugs such as arsenic, uranium nitrate, opium and its salts, and a general tonic régime.

The theory of multiple causes serves to explain many cases otherwise inexplicable. Sir J. Rose Bradford says "diabetes is not an entity, but a clinical label attached to a number of different conditions with varied origins, different morbid anatomy, and liable to follow different courses."

Acetonuria, Acidosis, and Diabetic Coma.—These arise from the defective metabolism of fat; the fat does not undergo complete oxidation to CO_2 and water; some remains in the stages of β-hydroxy-butyric acid, diacetic acid, and acetone. The carbohydrates were at one time believed a cause of acidosis; but the contrary is the fact. A sudden and complete withdrawal of carbohydrates gives rise to nausea, vomiting, rapid loss of flesh, the

odour of acetone in the breath, acetone bodies in the urine, increase of ammonia, and sometimes coma. If the patient is now given some carbohydrates, the symptoms will disappear. This effect follows the consumption of ordinary carbohydrate foods; but galactose, lovulose, glycerine, lactic acid, tartaric acid, and citric acid definitely inhibit the production of acetone bodies. Acetonuria and acidosis are especially liable to follow a strict diabetic or carbohydrate-free diet, insufficiency of food, excess of fat or protein.

The Diet for Diabetes Mellitus—(1) **Carbohydrate-free or Strict Diabetic Diet.**—It is beneficial for a diabetic person to follow definite rules. It was formerly considered that if the glycogenic function is suspended and the body unable to use carbohydrates in diabetes, it is useless or injurious to force them on the body. Home was the first to employ alkalies and animal food alone with a view to a specific action. But the first acquisition of clinical knowledge respecting carbohydrate-free diet was obtained by Rollo in 1830. But nowadays nobody prescribes a strict diabetic diet; few people can endure for years a diet consisting only of animal food, cabbage, and salad. Experience has shown that such a diet does not cure diabetes, although it produces a temporary reduction of glycosuria. It is often followed by acidosis, acetonuria, and sometimes diabetic coma.

This diet differs from the Salisbury diet by containing much fat, it is less monotonous, and may consist of any of the following articles:

Meat.—It may consist of fat and lean meat of all kinds—fresh, dried, salted, or smoked; and boiled, baked, roasted, grilled, minced, or dressed with spices. It may be derived from domestic or wild animals: oxen, sheep, deer, antelopes, horses, pigs, hares, rabbits, or birds. *All organs may be eaten, except the liver.* The condiments allowable are salt, vinegar, mustard, pepper, cayenne pepper, horseradish, capers, and pickles (especially pickled cabbage, cucumber, kidney or snap beans, cauliflower, onions, walnuts, sauerkraut), and a small quantity of piccalilli or chutney.

Soups and broths of every kind which do not contain carbohydrates. They may be made of any animal substance, except the liver—*e.g.*, ox-tail soup, bone soup, mutton broth, veal broth, chicken broth, game soup, oyster soup, snail soup, bisque soup; soup made of eggs, milk, or cream, and extract of meat; essence of beef, meat juice, and extracts of meat. The soup must *not* be thickened with flour, oatmeal, maize, lentils, bean-flour, pea-flour, barley, rice, vermicelli, macaroni, peas, beans, or other farinaceous material. It may be flavoured with mint, thyme, marjoram, savory, basil, bay-leaf, parsley, green celery, leek, onion, garlic, shallot, chives, cloves, allspice, pepper, cayenne pepper, salt, mushroom, morel, truffles; and turnips, carrots, or swedes (providing the latter are removed after being boiled).

Fish.—All kinds of marine or fresh-water fish may be eaten fresh, dried, salted, smoked, or made into paste, providing no starchy or other carbohydrate substance is used. The condiments

which may be used with fish are salt, pepper, cayenne pepper, vinegar, lemon juice, butter, salad oil; mayonnaise consisting of salad oil, egg, and vinegar; anchovy sauce, prepared crab, lobster sauce; boiled cucumber, spinach, sorrel, fennel, or parsley. But no sauce can be allowed which contains flour, cornflour, arrowroot, sugar, or other carbohydrate.

Shellfish and all animals in shells may be eaten—*e.g.*, crab, lobster, clams, oysters, mussels, snails, shrimps, prawns, and echinoderms. The liver, of course, contains glycogen; therefore the "inside" of lobster, crab, and the liver of oysters, etc., should be forbidden.

Eggs may be given in any form known to the cook, except combined with flour. starch, sugar, etc.

Milk, Cream, Butter.—The amount of cream and butter should be unlimited; but milk should only be allowed in sufficient quantity to flavour tea or coffee, or to make certain confections. Junket, milk jelly, egg custard, egg-snow, egg soufflé, whipped cream, etc., should be sweetened with saccharin.

Jelly made from meat, cow-heel, gelatin, isinglass, agar-agar, and Iceland or Irish moss may be allowed; they may be sweetened with saccharin.

Cheese.—Most varieties may be eaten when ripe.

Vegetables.—The diabetic person loses daily a large quantity of mineral substances in his urine; this loss should be made good by the consumption of vegetables. Cabbage and all other *Brassicæ*, when quite green, are recommended. Turnip-tops, beet-chard, celery-tops, spinach, green beans, endive, lettuce, watercress, radishes, cucumber, vegetable marrow, pumpkin, squash, mushrooms, green artichokes, Jerusalem artichokes, turnips, mustard and cress, green onions, sorrel, and dandelion leaves, are allowed for most cases. Cooked vegetables should be boiled in a large amount of water.

Nuts.—Brazil nuts, butternuts, almonds, filberts, walnuts, peccans, pine-nuts, and roasted peanuts are allowed in moderation. *Chestnuts are forbidden.*

Fruit which contains less than 5 per cent. of carbohydrate may be allowed in moderation, unless very strict dieting is attempted—*e.g.*, olives, strawberries, raspberries, blackberries, bilberries, and an occasional apple, pear, orange, or plum.

Beverages.—Pure water, distilled water, or aerated water (Puralis, Salutaris), is the best beverage. Tea, coffee free from chicory, cocoa made from nibs, maté, and guarana, are allowed. They may be sweetened with saccharin, flavoured with cream or lemon. The patient also may have beverages made of juice of lemons and limes, citric acid, tartaric acid, or cream of tartar; unsweetened soda, potash, or other mineral waters; and the alkaline waters of Vichy, Vals, Ems, Royat, Carlsbad, or Contrexéville. A little unsweetened gin, whisky, brandy, dry sauterne, Chablis, hock, Moselle, or Burgundy, may be taken.

Forbidden Foods.—Liver, inside of crabs and lobsters, cockles,

mussels; sausage, polony, black pudding, and commercial pastes of fish, fowl, meat, shrimps, etc. (they usually contain liver and a proportion of bread or flour). Jelly containing sugar. Bread and cakes of every kind and form; biscuits; confections, such as meringue, marzipan, royal icing. Pastry, milk puddings, and cereal or farinaceous foods. Potatoes, sweet potatoes, yams, beetroots, carrots, parsnips; blanched vegetables—*e.g.*, white heart of cabbage, cauliflower, broccoli, celery, onions, seakale, salsify, scorzonera; green peas, kidney or snap beans, broad beans, and asparagus. Sweet fruits—*e.g.*, grapes, oranges, melons, tomatoes, pears, apples, mulberries, cherries, plums, etc. Jam, marmalade, preserves, crystallized fruit, preserved ginger, guava jelly or marmalade, fruit jelly, honey, treacle, sugar, and chestnuts. Beer, ale, stout, porter, sweet wines, liqueurs, syrups, prepared cocoa, coffee with chicory or other adulterants, sweet mineral waters, and other beverages containing sugar or dextrin.

Effects of Carbohydrate-free Diet.—*In moderate cases* the excretion of sugar diminishes at once, and ceases in less than a week; but the total excretion of nitrogen rises, the ammonia increases, and the urine may give a reaction for diacetic acid and acetone. *In severe cases* the urine is not rendered sugar-free; the patient continues to excrete sugar manufactured from fat or protein. In a few days the urine gives a deeper reaction for diacetic acid, the nitrogen excretion rises, indications of acute acidosis soon appear, and there is a risk of coma after ten or fourteen days' use of the diet.

(2) **Modified Ordinary Diet.**—Failure of the strict diabetic, or carbohydrate-free diet, to prevent the excretion of sugar has caused that method of treatment to be almost entirely abandoned. The diet should be arranged after the use of test-meals. The existence of sugar in the urine to the extent of 0·1 or 0·2 per cent. needs antidiabetic diet. If the total daily excretion of sugar is less than 70 grammes ($2\frac{1}{2}$ ounces), it is a mild case; if it exceeds 70 grammes, it is a severe case, probably complicated by acetonuria. The following **test of toleration** is safe: Let the patient take the diet he is accustomed to for three days; during this period all his food must be carefully weighed, and the amount of carbohydrate calculated from the tables of composition. On the third day, let all the urine be collected, mixed, and measured; the percentage and total sugar excreted should be estimated. *The patient's tolerance of carbohydrates* is the carbohydrate in the food *minus* the sugar in the urine. If the patient excretes more sugar than he consumes, he has no tolerance—he has the disease in a severe form. If the patient has been in the habit of consuming 250 grammes of carbohydrates, and he excretes 220 grammes of sugar daily, his tolerance for carbohydrates is only 30 grammes. Alkalies should now be given daily, and the carbohydrate *gradually reduced* until the sugar disappears from the urine; if this is done slowly, the glycosuria may disappear when the carbohydrate reaches 70 grammes. This diet should be maintained for a time, perhaps for two months. If the

glycosuria does not return, the carbohydrate may now be increased gradually until the sugar reappears. The actual tolerance is somewhere between the points at which the glycosuria goes and reappears. The carbohydrate must be varied until the actual tolerance of carbohydrate is reached, and the allowance fixed at 10 grammes below it. Some carbohydrate foods cause a greater excretion of sugar than others; but the tolerance for each food can be tested in turn, until a dietary suitable for the patient is built up.

The Total Allowance of Food.—Many patients have an enormous appetite and great thirst. But it is unnecessary for them to have a great bulk of food, providing it is of the right kind. The hunger of a diabetic patient is due to his inability to utilize sugar, and, in a large proportion of cases, to the consumption of foods which are useless to him—*e.g.*, bread and other starchy foods. Hunger is moderated by proper food, but is never appeased by consuming an unlimited amount of improper food. A number of observations were made on diabetic persons by Pautz,[1] who arrived at the conclusion that the total *energy requirement* does not vary from that of a healthy individual; but an allowance should be made for the sugar lost in the urine. If a man excretes 70 to 100 grammes of sugar daily—*i.e.*, a loss of 287 to 410 calories, sufficient animal food should be given to cover the loss. The weight of diabetic persons ought to be maintained with an allowance of 40 to 45 calories per kilo of body-weight. An excess of food should be avoided, because the digestive and metabolic functions are liable to be disturbed thereby and the system laden with the products of imperfect metabolism.

The Protein Requirement.—If a diabetic person consumes an ordinary mixed diet, he requires a larger amount of protein and fat, for the simple reason that he is unable to utilize the normal amount of carbohydrate. The metabolism of proteins is the same in diabetic and normal persons—that is to say, the nitrogen balance is kept in equilibrium with equal quantities. If it is desired to determine the amount of protein needed by any patient, it can be done by finding out how much nitrogen is excreted. Protein $=N \times 6{\cdot}25$; and meat in general (beef, mutton, game, fowl, fish, etc.) contains 3·2 per cent. of nitrogen. If the urine contains 16 grammes of nitrogen daily, the protein required is $16 \times 6{\cdot}25 = 100$ grammes per diem; and this amount of protein would be contained in $(16 \times 100) \div 3{\cdot}2 = 500$ grammes, or $17\frac{1}{2}$ ounces of meat.

The total amount of food, however, must be enough to meet the calorific requirements or expenditure of energy; and it may be necessary to make up any deficiency with animal food. Sufficient reasons have been given for the abandonment of the carbohydrate-free diet. One important reason must be insisted on: It is probable that the only source of muscular potential energy is a carbohydrate, and if it is not contained in the food, it must be manufactured in the organism out of protein or fat; 40 grammes of sugar may be

[1] *Zeit. f. Biol.*, 1895, xxii. 206-238.

produced from 100 grammes of protein. But the call for sugar often leads to the manufacture of more than the organism can utilize; consequently the urine may contain sugar when there is none in the food. Diabetic persons should not be allowed more than 160 to 180 grammes of protein a day, although some authorities fix the upper limit at 200 grammes. Excess of animal food is particularly contra-indicated in old age, gouty diabetes, albuminuria; and in those cases where nitrogenous food increases the glycosuria more than a limited amount of carbohydrate does.

The Allowance of Fat.—It is usual to allow an unlimited quantity of fat to help the consumption of a large amount of green vegetables, and to make good the deficiency of food due to the withdrawal of carbohydrate. It is believed that the consumption of alcohol—first-class wine or spirit—promotes the digestion and absorption of fat, and reduces the risks of lipæmia and acidosis. When thus assisted, the assimilation of fat by diabetics is normal. Strauss[1] gave a diabetic the following diet for thirty-three days: Meat 12½ ounces, bacon 3½ ounces, butter 5½ ounces, salad 5 ounces, sauerkraut 5 ounces, whisky 1½ ounces, and oil 1 ounce. It contained 280 grammes of fat, and was practically carbohydrate-free; an examination of the fæces showed 92 per cent. was absorbed.

The consumption of a large quantity of fat should be encouraged. But it may be injurious; therefore the physician should keep a look out for acidosis and acetonuria. Acetone bodies arise from the defective metabolism of fat. Acetonæmia can be produced in healthy persons by cutting off carbohydrates; if fat is then given, the acetonæmia will increase, but if sugar be given instead, it will cease. The same occurs in diabetics. Moreover, butter, cheese, and cream increase the acetone bodies more than other fats. Therefore when a fatty diet is followed by acetonuria, acidosis, lipæmia, or lipoidæmia, the total amount of fat in the food ought to be reduced; the patient should only be allowed fat meat, bacon, ham, eggs, margarine, and oil; and butter, cream, and cheese should be prohibited until acetonuria ceases or is much diminished.

The Carbohydrate Allowance.—A complete abstinence from carbohydrates compels the organism to utilize or eliminate the harmful reserves of sugar and rests the glycogenic functions. Under such treatment the glycogenic function may improve and the patient's tolerance for carbohydrates rise in two months from 30 to 80 or even 100, grammes daily. The degree of tolerance may also be improved by judicious muscular exercise. But it has been shown that the carbohydrate-free diet does not prevent acetonuria and acidosis. The reason is due to the fact that the metabolism of fat, as well as carbohydrate, is defective. Moreover, the potential energy of the muscles is constantly and without variability derived from carbohydrate. Therefore carbohydrate is essential, and protects the muscles from wasting in proportion to the degree of

1 "Ein Beitrag zur Kentniss der Fettresorption in Diabetes Mellitus," i., p. 14, Strassburg, 1893.

toleration. The amount of energy expended in ordinary muscular work is about 450 to 550 calories per diem; and this would be supplied by about 100 grammes of carbohydrate. This rule, therefore, may be stated: *The supply of carbohydrates should be gradually cut down until it is merely sufficient to provide energy for the muscular work—viz., 100 grammes daily.* If the nutrition and weight of the body are maintained, if the sugar in the urine does not increase, and if acetone bodies are absent from the urine, that quantity of carbohydrate should be allowed daily. When the degree of tolerance is less than 100 grammes daily, the carbohydrate may be reduced below that amount if means are adopted, such as rest in bed, to reduce the mechanical or muscular work of the body; but the effect must be carefully watched. If the patient is on a diet equal to his carbohydrate tolerance, he may live indefinitely without glycosuria; but when the carbohydrate is above his tolerance, a part of it will be eliminated in the urine, and part retained in the cells of his tissues. In an ordinary case of diabetes there is some power of utilizing carbohydrates, there is no loss of nutrition, the nitrogen balance is maintained, and the sugar in the urine is derived from the food alone. In severe cases there is little power of utilizing carbohydrates; the organism loses weight, the tissues are successively destroyed, the nitrogen balance is upset, the organism cannot utilize the carbohydrates manufactured from the proteins or fat of his food or tissues; the sugar eliminated exceeds the carbohydrate consumed, it comes from carbohydrates, proteins, and fats, and is probably attended by acetonuria.

The selection of carbohydrate food should not be limited to bread, potatoes, rice, peas, or oatmeal; if the table on p. 476 is properly used, the patient's diet can be varied from day to day, and the consumption of carbohydrate gauged fairly well. A much larger variety of foods may be used by reference to the table of compositions (pp. 9-20) in the Introductory chapter. Torrefied bread, bottom crust, and toast have some of their starch converted to dextrin; but it is a fallacy to suppose they are better adapted than ordinary bread for diabetics; *they are concentrated carbohydrate foods.* **Diabetic breads** should be carefully scrutinized; the proportion of carbohydrate in them ought to be known; if it is unknown or variable, they should be forbidden. Gluten flour should contain 35 per cent. of protein; but it is never free from carbohydrate; Kraus of Carlsbad asserts that only three out of nineteen specimens of gluten bread analyzed contained less than 30 per cent. of starch; five contained 30 to 40, four from 40 to 50, two from 50 to 60, and four over 60, per cent. of starch. Cakes made of almond flour, grated Brazil nuts, cocoanut, soy beans, and proteins are valuable. Various recipes for their preparation are sent out with Alcuronat, Glidine, Roborat, Protene, Plasmon, and other protein foods which are useful to the diabetic. Some confectioners manufacture diabetic cakes, biscuits, and bread, which are guaranteed to be starch-free and sugar-free.

The Potato Cure.—Ripe potatoes contain 19·5, new or unripe potatoes 15, per cent. of carbohydrate. Now, 100 grammes of carbohydrate are contained in about 19 ounces of potato, or 6⅝ ounces of white bread, or 5⅜ ounces of dry toast. Therefore it is more rational to allow potato than bread. Moreover, potatoes are bulky, they will take up a considerable amount of fat, and are suitable as the chief source of carbohydrate. Dujardin-Beaumetz said they cause a smaller excretion of sugar than an isodynamical quantity of bread, and he considered them superior to gluten bread. Strauss also found them better tolerated than bread. Mossé used potatoes as a "cure" for diabetes, prescribing 2¼ to 3¼ pounds daily; in nineteen out of 20 cases the glycosuria was reduced, thirst diminished, and there was improvement of the general condition. These results were chiefly due to potassium salts. Sawyer prescribed a cake made of potato flour, bran, yeast, eggs, and butter. Sternberg recommended that the potatoes should be deprived of as much starch as possible. This may be done by reducing them to a pulp, throwing it upon a linen strainer, and washing out the starch by a stream of water. The residue will contain much less starch than boiled potatoes, and it can be used for preparing many dishes.

THE AMOUNT OF CARBOHYDRATE IN 1 OUNCE OF FOOD.

	Grains.	Grammes.		Grains.	Grammes.
Almonds.. ..	75	4·90	Melon	23	1·49
Apples	55	3·58	Milk	20	1·29
Artichokes, Jerusalem	61	3·95	Oatmeal	275	17·12
			Onion	47	3·04
Arrowroot ..	364	23·50	Orange	36	2·33
Asparagus ..	14	·90	Parsnip	55	3·56
Banana	92	5·96	Pears	60	3·95
Biscuit	308	19·95	Plums	64	4·15
Blanc-mange ..	100	6·48	Potato	96	6·18
Brazil nuts ..	32	2·07	Pudding: Rice ..	106	6·86
Bread: Brown ..	217	13·06	Semolina ..	76	4·92
White.. ..	228	14·77	Tapioca ..	81	5·24
Cabbage.. ..	22	1·42	Yorkshire ..	67	4·34
Carrot	48	3·11	Spinach	15	0·97
Cauliflower ..	22	1·42	Starch—*e.g.*, corn starch	394	25·41
Cherries	48	3·11	Strawberries ..	29	1·88
Chestnuts ..	324	21·20	Sugar	460	26·40
Cornflour ..	343	22·22	Tomatoes ..	17	1·10
Cream	20	1·29	Vegetable marrow	23	1·49
Filbert nuts ..	61	3·95	Walnuts	65	4·26
Grapes	66	4·27	Wheat flour ..	328	21·25
Very sweet ..	110	7·12	Zwiebach ..	321	20·70
Green peas ..	61	3·95			
Kidney beans ..	26	1·68			

Artichokes and Jerusalem artichokes contain inulin, but no starch; late in the year they also contain levulose. Chinese artichokes (*Stachys tuberifera*) and dahlia tubers also contain inulin. All these are suitable foods for the diabetic. Inulin is a gummy substance yielding levulose on hydrolysis; but it is doubtful whether levulose is produced from it in the alimentary canal. When starving animals are fed with levulose, it increases the glycogen in the liver; but inulin has not the same effect; hence it is doubtful whether inulin is a useful food. Levulose, to the extent of 1½ ounces a day, is tolerated better than ordinary sugar; but not by every patient.

The Oatmeal Cure.—Oatmeal contains 67·5 per cent. of carbohydrate—*i.e.*, 8 or 10 per cent. less than wheaten flour. But the *toleration* of oatmeal in many cases is twice as great as that of bread; it should be tested in each case. It may be given in porridge, pudding, and cake. Von Noorden's "oatmeal cure" consists of porridge made in the following proportions: Oatmeal 5, albumin 2, butter 6, parts. Each meal may consist of 1 ounce oatmeal, 1 ounce butter, and two eggs. But the eggs may be replaced by Aleuronat, Roborat, Glidine, etc. A little cognac, whisky, wine, or coffee, may be allowed, but no other food. It is beneficial in many cases; but it should not be continued too long at one time, lest diarrhœa, nausea, œdema of the legs, or other signs of discomfort arise. It may be given in alternation with other "cures"—*e.g.*, after two or three days of strict carbohydrate-free diet, the patient may have three or four days of the oatmeal cure, then the potato cure, or two or three days of turnips, butter, and greens, and so on, in a cycle. Irish moss, Iceland moss, dulse, salep, and agar-agar, are useful foods in many cases.

The Personal Equation.—The food which suits one patient admirably may be bad for another. Oatmeal, potatoes, rice, macaroni, fruit, milk, dextrose, levulose, saccharose, lactose, etc., may each be tolerated better than the others. There is a personal equation for the utilization of sugar, and there is also a personal equation with regard to starch and fat. It is only by careful analysis of the urine after the addition of a fresh food that we can gauge its tolerance and effects.

Milk in Diabetes.—On account of its lactose, milk has been excluded from the diet by many authorities. Bouchardat forbade its use in all cases, except when there is albuminuria, some visceral lesion, or threatened uræmia. Donkin prescribed skim milk alone for weeks together, and Winternitz claims to have cured many diabetics by milk alone. Its value depends on the toleration for lactose. In ordinary dieting, it is unnecessary to forbid the use of enough milk to flavour tea or other beverages; 1 ounce of milk contains only 0·75 gramme (11 grains) of lactose. Cream is always allowed, but it should not be forgotten that it contains as much lactose as milk does. Sugar-free milk can be obtained from Callard and Callard of London; but a solution of casein in water, with some cream added to it, is a good substitute, and nearly sugar-free. **Almond milk** may also be used.

Artificial Substitutes for Sugar.—The food of diabetic persons may be sweetened by saccharin, saxin, dulcin, sucrole, etc. These substances have no food value; they do not spare the tissues, nor yield energy. Many diabetics become accustomed to unsweetened food; others crave for sweets. Dyspepsia and neuralgia in the solar plexus occur when saccharin, etc., are used to excess; and it may be injurious to the kidneys.

Alcohol in Diabetes.—The patient should not have malt liquors or sweet wines. He may have pure whisky, cognac brandy, unsweetened gin, *dry* wines—*e.g.*, sauterne, Chablis, and Burgundy. Champagne *sans sucre* contains only 20 grains of sugar in 1 quart—about 1 per cent.; Rhine wine and hock may be obtained containing only 0·004 to 0·15 per cent. of sugar. A limited amount of alcohol is valuable; it replaces fat and carbohydrate as a source of energy and protector of protein, and assists the absorption of fat. The amount may range from 2 to 5 ounces of whisky or brandy, or from 10 to 20 ounces of wine daily, according to its strength.

Severe Diabetes.—This may be divided into two classes: (*a*) *Without acetonuria.*—If there is sugar in the urine when the carbohydrate is reduced to 70 grammes daily, there probably would be sugar with carbohydrate-free diet. Let the patient be given a test diet consisting of 18 or 20 ounces of cooked meat (or 8 ounces of meat and three eggs), 2 pints of sugar-free milk, 4 ounces of carbohydrate-free bread (Caseoid, gluten, Protene, etc.), with plenty of butter, boiled greens, and salad. If there is no diminution of sugar in the urine, it is useless to give a strict diet; the power to utilize sugar is very deficient. The amount of carbohydrate to be allowed in such a case must depend on the general condition, the nutrition, loss of weight, and proportion of sugar in the urine. It may be necessary to restrict the consumption of protein as well as carbohydrate. One food after another should be tried, until a list is obtained which causes the patient to excrete the smallest amount of sugar.

(*b*) *With Acetonuria.*—In these cases there is defective metabolism of fat, carbohydrate, and protein; it is therefore absurd to prescribe animal food and greens to the exclusion of starch and sugar. As a matter of fact the excretion of sugar in these cases is very little influenced by diet, and we should be satisfied if the glycosuria can be kept within moderate limits—*e.g.*, the excretion of 100 grammes of sugar daily. Any change of food must be brought about gradually; a sudden change would accentuate the acetonæmia, and might precipitate coma. The following dietary may be useful:

Breakfast.—Tea or coffee with thick cream; fat ham or bacon and two eggs; 2 ounces of brown bread, plenty of butter.

Midday Meal.—Clear soup, containing beef marrow; boiled or broiled fish, with butter; fat meat, game, poultry; boiled vegetables and butter; 2 ounces of bread, butter, ripe cheese; whisky and alkaline-water.

Teatime.—A cup of tea or coffee with cream; diabetic cakes of almond, cocoanut, etc., 1 ounce.

Evening Meal.—Hot or cold meat, fish, or eggs; boiled vegetables and butter; 2 ounces of bread-and-butter, cheese; whisky and alkaline-water.

The bread, cakes, and vegetables may be reckoned as 7 ounces of bread, containing 100 grammes of carbohydrate. A pound of potatoes would contain about the same quantity of carbohydrate, and should now and then be eaten in place of bread; or bread and potatoes may be both used up to the limit. The patient must not be allowed to overfeed himself. Hunger is due to loss of sugar; thirst to polyuria. It is better for the patient to suffer hunger than run the risks of coma from acidosis. In mild cases of diabetes fat is borne well throughout its course; but in severe cases the oxidation of fat fails, the sugar manufactured from it is not utilized, and the fatty acids are not wholly oxidized to CO_2 and water. In many cases butter and other fats containing butyric acid are badly borne, and their use must be restricted. The fat of eggs and milk is usually well tolerated. When people cannot afford a large amount of animal food, milk is for them the best source of protein and fat; and it may be pointed out that 4 pints of milk contain 103 grammes of carbohydrate.

It should be observed that acetonuria does not mean the case is hopeless; many patients live for years after its appearance. Weintraud says it is only dangerous when the metabolism of nitrogen becomes disturbed. But it necessitates the allowance of more carbohydrate, and a simultaneous reduction of fat and protein. An attempt should be made to re-establish the equilibrium of the nitrogen balance; to do this, it may be necessary to reduce the protein to 100, 80, or even 60, grammes daily. The amount of fat must be reduced, temporarily at any rate, and butter, cream, cheese, or other articles containing volatile fatty acids, must be excluded from the diet. The amount of carbohydrate to be allowed cannot be fixed; it must depend on its effects. Nobody doubts the value of carbohydrates and their ability to relieve the symptoms of acidosis; but the ultimate good of the increased allowance is doubted. The lowest quantity of carbohydrate which will prevent acetonuria is 72 grammes daily; it never increases acetonuria, always tends to check it, but it is very likely to increase glycosuria. The acetone bodies arise from too strict dieting of the diabetic; the food does not contain enough carbohydrate for muscular energy, it is manufactured from protein and fat, and when the metabolism of fat is defective, acidosis occurs, and the patient is liable to coma.

Milk is an exceedingly useful food in severe cases. Its lactose is valuable, and often tolerated better than other carbohydrates. There may be an increased glycosuria after taking milk, in respect of which there is a fallacy, which was exposed by Voit, as follows: A diabetic person was strictly dieted until the sugar in his urine was very low. He was then given 100 grammes of lactose daily, and the glycosuria at once increased; *but the excreted sugar was not lactose;* it was glucose (*dextrose*) derived from the proteins and fats. Lactose is utilized more easily than dextrose in these cases; therefore when milk is consumed, a quantity of glucose corresponding to the consumed lactose may be excreted.

The oatmeal cure of Von Noorden is very good in some cases of acetonuria. The potato cure may also be tried. Strauss found 100 grammes of bread is equal to 200 grammes of oatmeal or 300 grammes of potato in causing glycosuria. As a " cure," 3 pounds of potatoes daily are recommended by Strauss, Mossé, and others, no other carbohydrate being allowed. In many cases of diabetes 1 pound of potatoes would be sufficient. When the full amount is eaten, a rapid reduction of acetonuria is observed. Potatoes may be utilized as a means of introducing fat; they may be taken as " fried chips," fat being used in cooking.

Vegetarian Diet for Severe Diabetes.—The starch and other carbohydrates of vegetables are contained in cellulose envelopes, and, excepting where the cellulose is arranged in thin layers, alternating with amylose or granulose, many vegetables are not very quickly digested. The fibres of many plants are coated with ligno-cellulose, and this substance increases with the age of the plant. Cellulose consists largely of **dextran,** a polymer of dextrose. Iceland moss consists mainly of hemicelluloses, of which dextran is the chief; Irish moss and agar-agar consist chiefly of the hemicellulose called **galactan** ; the Turkish salep of **mannan**; and dulse of a mixture of pentosans. These celluloses and hemicelluloses are digested by man with extreme slowness; they yield dextrin, dextrose, galactose, and mannose. It has been shown that toleration of carbohydrates is in proportion to their slowness of digestion, and galactose is tolerated better than dextrose. The above-named substances are all of very low food value, and afford very little nourishment to the body. It is idle to say they are useless. Digestion experiments show a relatively small absorption; but the fact remains that algæ and lichens are staple foods for human beings in some regions of the earth. When boiled in water, they yield a gelatinous or gummy substance. They contain a bitter principle, which can be removed by washing the fronds in a weak alkaline solution. The material may then be dried, reduced to a powder, and used for making bread, cakes, and puddings.

Ordinary lacto-vegetarian dietary is sometimes beneficial in severe diabetes: milk, potatoes, oatmeal, or other cereals and legumes (beans and peas). This is necessarily a low protein diet. The diminution of protein often increases the tolerance of carbohydrates. The patient is satisfied with less food—say, 25 calories per kilo, or a total of 1,600 to 1,800 calories daily. The reaction of the diet is alkaline; under its influence the urine becomes less acid, acetone bodies disappear, coma is warded off and the kidneys are spared. It has been shown that an excess of proteins increases glycosuria, that egg-albumin is tolerated best of all, and other proteins in the following order: Whole egg, vegetable proteins, milk proteins, and meat proteins, the latter being tolerated least of all. Therefore a diet consisting largely of nuts, beans, peas, fat bacon, cabbage, turnips, salads, and salad-oil, is as likely to give good results as a diet containing animal foods.

Fat in Severe Cases.—Acetone bodies result from faulty metabolism of fat, and are immediately derived from the lower or volatile fatty acids. Butter, cream, and ripe cheese contain such acids, and in bad cases the patient should be forbidden to eat them. Eggs, beef fat, mutton fat, and salad-oil may be allowed; they do not contain volatile fatty acids. Stern of Chicago prescribed 10 to 40 egg-yolks daily; and Pollateschek ordered large quantities of meat fat as a cure for acetonuria.

Rectal Injections of Glucose.—In cases where these foods do not relieve the symptoms of acidosis the carbohydrate should be injected into the colon. One ounce of glucose dissolved in 4 ounces of water should be injected two or three times a day. Under this treatment the acetonuria may entirely disappear, glycosuria diminish, and the general condition improve.

The Alkaline Treatment.—Alkalies are beneficial for acidosis and acetonuria. In bad cases from 1 to 2 ounces of bicarbonate of soda should be given daily, in doses of 1 to 2 drachms. The only contra-indication to its use is extremely rapid emaciation; in such cases it is prejudicial. Its effects should be closely watched in all cases—it may cause gastric disturbances, diarrhœa, and œdema of the extremities. There is no need to continue large doses of soda a long time; when the urine becomes neutral, the dose may be reduced to ½ ounce a day. All alkalies act on the liver, encourage the storage of glycogen, check the output of sugar, increase the toleration of carbohydrates, abate the thirst, neutralize acidity, and in some cases cause a disappearance of sugar and acetone from the urine. Alkalies should always be given when transferring a patient from one kind of diet to another, and particularly when the diet is poor in carbohydrate. Residence for a few weeks at Vichy, Carlsbad, Neuenahr, and other places where the water is strongly alkaline is often very beneficial, when associated with proper feeding.

Diabetic Coma.—When there is marked acetonuria, sodium carbonate should be given before meals, as directed above. If the patient is very drowsy, an intravenous injection of saline solution containing 1 or 2 per cent. of sodium carbonate may be used. The best mode of feeding a comatose patient is to wash out the rectum and inject a solution of dextrose and white of egg every few hours.

Digestive Troubles.—Ordinary digestive derangements require the same treatment as in other people. But the gastric crises to which diabetics are subject are of very bad augury. The tongue becomes foul, sometimes presenting a streak of black fur down the centre, the mouth dry, and the breath has an odour recalling that of chloroform ; the urine contains acetone, but not always diacetic acid. The crisis consists of a sudden pain in the abdomen, swelling, and eructation of gas, followed by nausea or vomiting, and sometimes diarrhœa. Nausea renders oral feeding temporarily impossible. The treatment consists of applying warmth to the abdomen, clearing out the bowels by enemata, and feeding with

rectal injections of dextrose or levulose, and white of egg. The patient may drink an effervescing solution of sodium bicarbonate and tartaric acid with excess of soda. Apollinaris and other alkaline waters are beneficial. When the crisis is passing off, give milk, chicken broth, mutton broth, weak tea, brandy, and alkaline waters. The diet which the patient has been accustomed to may need readjusting. He must be put on foods which will be useful to a person with acetonuria. The predominance of animal foods should be checked ; foods containing cellulose or hemicellulose—*e.g.*, inulin—may be given with advantage. Alkalies, alkaline waters, tartaric acid, citric acid, lemon-juice, or lime-juice should be given. "Bilious attacks" should in future be looked on with suspicion.

Tuberculosis in Diabetes.—Post-mortem examinations show that tubercle complicates 30 to 40 per cent. of diabetes. When this complication exists, the diet must be abundant—viz., 35 to 45 calories per kilo of body-weight, 2,500 to 3,300 calories per diem, and more than that if the patient performs manual labour. But the diabetic diet should be followed in most cases—that is to say, the allowance of carbohydrate should be within the degree of tolerance. Open-air treatment should not be enforced, unless the patient is living in a warm, dry climate.

Gouty Diabetes.—This variety usually involves a disturbance of most of the metabolic functions. The dietetic treatment should neither be that of typical gout nor diabetes. If the patient is put on a diet suitable for typical cases of either disease, he will go from bad to worse. The food must be of the ordinary kind, light, nourishing, such as would be suitable for catarrh of the stomach. Ordinary bread, milk puddings, and vegetables must be allowed in moderation. Tender meat, fowl, and light fish must be prescribed in such quantities as their weakened organism can metabolize; a large amount would be injurious. A little dry champagne, or well-matured port, containing a minimum of alcohol and ether, may be allowed. The object of treatment is to build up and nourish the enfeebled frame, strengthen the heart, stimulate the metabolic glands, and encourage the physiological processes in general. The articles on Catarrh of the Stomach and Chronic Hyperæmia of the Liver should be read in this connection. Treatment at Harrogate, Bath, Llandindrod, Carlsbad, Marienbad, Neuenahr, etc., is useful.

Albuminuria in Diabetes.—The cause of the albuminuria should be found and treated. It may originate in gouty diabetes, renal changes, arterio-sclerosis, alimentary toxæmia. The diet suitable for these conditions should be given as far as possible, taking care to keep the carbohydrate within the degree of tolerance. When the diabetes is of pancreatic origin, the occurrence of albuminuria does not require any change from the diabetic diet. When tube-casts and albuminuria become a constant feature in a case of diabetes, an occasion has risen for reconsideration of the diet. Milk is valuable for such cases.

Glycosuria during Pregnancy.—Sugar occurs in the urine of many women during pregnancy and lactation; it may be lactose or glucose, or both. It is sometimes due to genuine diabetes. The liver is very liable to be upset during pregnancy, and this may produce hepatic diabetes. As a general rule it disappears under a mild antidiabetic diet. About 120 grammes of carbohydrate should be allowed—*e.g.*, 1 pint of milk, 3 ounces of bread or toast, and 8 ounces of potato—with meat, fish, eggs, and fresh vegetables. Frequent examinations of the urine should be made.

Diabetes in Children.—This is frequently acute, and of pancreatic origin. The treatment required does not differ essentially from that of adults. If the urine does not give a reaction for diacetic acid, the carbohydrates should be reduced to the point of tolerance. If the urine gives that reaction, or acidosis threatens the patient, the greatest caution must be exercised in the reduction of carbohydrate.

Senile Glycosuria.—This is probably not true diabetes, but a failure of metabolism in general. The urine contains sugar, but there may be neither polyuria, polydipsia, nor polyphagia. If the senile change is accompanied by atheroma, gangrene may originate from a slight injury. In all cases of senile glycosuria, extreme care is required in regard to the diet. It is extremely risky to put them on carbohydrate-free diet. But the tolerance of carbohydrate is low, and the allowance ought to be cut down somewhat. Milk, eggs, fish, tripe, fowl, rabbit, lamb, and rarely cooked beef, should be the staple foods. The necessity for protein is naturally diminished after sixty-five years of age; therefore the allowance may be gradually cut down to 60, 50, or even 40 grammes a day with advantage to the patient. Fat of all kinds is permissible. Oatmeal should be recommended; of course, it must be taken in moderation. The allowance of bread and potato should be slightly limited, but the effect of reducing carbohydrates ought to be closely watched, lest acidosis arise. The total value of the food should depend on the activity of the patient; it should not be so high as for a person in middle life, and may be reduced to 1,800 or 1,900 calories for men, and less for women.

Diabetes Insipidus.

The most conspicuous signs are polydipsia and polyuria. The pathogeny is not clear. It appears to be due to reflex causes, neuropathic conditions, interstitial nephritis, irritation from a large prostate, etc. Cases of true essential polyuria are sometimes due to adrenalinæmia, arising from overaction of the chromaffin system. They have been traced to a violent shock, injury to the brain, etc. The metabolism of nitrogen is often largely increased, owing to the flow of a large amount of fluid through the tissues.

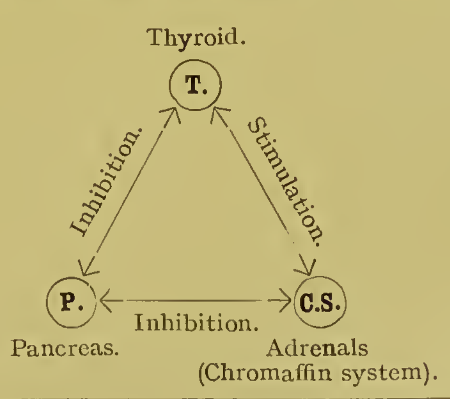
The treatment is not very satisfactory. No readjustment or alteration of the food appears to influence its course. The demand

for protein may be much increased; this can only be determined by an estimation of the nitrogen in the urine. It is seldom, however, that the actual requirement is more than 1·7 or 2 grammes of protein per kilo; but in exceptional cases 3 grammes per kilo are necessary to meet the loss from exaggerated metabolism. The loss of weight is due to destruction of fat to provide water. When all the fat in the body is used up, the tissue proteins will be used. Rational feeding is all that is necessary. In addition to some increase of protein, the patient should have plenty of fat, especially butter, cream, milk, salad-oil, cod-liver oil. The wasting of the body may be prevented by generous feeding. Concentrated foods, such as meat-powders, somatose, casein preparations, extract of malt, etc., will be useful. No good results from restriction of carbohydrates. There is a marked intolerance of common salt, and in some patients it is easy to cause salt fever by pushing its use to excess. "Dry diet," or limitation of liquids, has been found beneficial when the primary symptom is polydipsia, but injurious, and even dangerous, when polyuria appears first. It causes such discomfort that very few patients persevere with this diet. The relief of thirst is important; dryness of the mouth may be checked by using sialogogues, and by masticating chewing-gum, rubber, dried prunes, horseradish, sweet-flag, curcuma, galangal, and other roots, which encourage the action of the salivary glands.

CHAPTER XVI

THE PANCREAS, THYROID, AND OTHER GLANDS

THE influence of the ductless glands on metabolism has not been recognized until recent years. A well-known work on Physiology, published in 1885, says: "These organs, included under the general title of **ductless glands**, seem to be the remains of organs which once have been of importance in the economy, but which, in the process of evolution, have come to play a subsidiary part." Since that time it has been discovered that these organs occupy an important and by no means subsidiary position, in the human economy. But it is especially since the discovery of internal secretions, hormones, and cellular enzymes, that these organs have "arrived," so to speak, and have been accorded a rank equal to their importance. The influence of one gland on another is best observed by stimulating or extirpating one gland, and observing the changes in the others. The brilliant researches of Eppinger, Ruddinger, and Falta[1] were made in that way. They arrived at the conclusion — (1) That there is a mutual inhibition between the thyroid and the pancreas, and between the pancreas and adrenals; (2) there is a mutual stimulation between the thyroids and adrenals, but the inhibition is greater than the stimulation; (3) extirpation or hypofunction of one gland leads to excessive activity or diminished activity of the other glands, according as the influence of the extirpated gland was stimulating or inhibitory. The following diagram is illustrative of these conclusions:



[1] *Zeit. f. Klin. Med.*, 1908 and 1909; also *Berl. Klin. Woch.*, 1909.

The Pancreas.—Removal of the pancreas is followed by (1) hyperglycæmia and glycosuria ; (2) hyperthyroidism, increased metabolism of protein, fats, and carbohydrates; (3) increased activity of the adrenals (chromaffin system), and excessive mobilization of carbohydrates; the metabolism of carbohydrates being hindered by loss of the internal secretion of the pancreas. We need not return to the subject of diabetes mellitus.

The symptoms common to pancreatic diseases are glycosuria (possibly maltosuria), fatty diarrhœa, deficient digestion of fat and muscle, and epigastric pain. In pancreatic lithiasis there are fatty stools, defective digestion of meat, occasional diarrhœa, and, finally, diabetes. In neuroses of the pancreas, fatty stools and undigested meat are common; but diarrhœa is not an ordinary symptom. Glycosuria, accompanied by the signs of a transitory pancreatitis, may occur in infectious diseases. The symptoms of acute pancreatitis suggest the occurrence of intestinal obstruction, there being a sudden attack of pain, followed by vomiting. In chronic pancreatitis there are digestive disturbances, epigastric pain and tenderness, progressive loss of strength, and the distinctive symptoms of pancreatic disease, which may be confirmed by Cammidge's reaction, and an examination of the fæces for trypsin.

The dietetic treatment of acute pancreatitis is the same as in other inflammatory conditions. Milk and its preparations should form the staple diet; custard, junket, jelly, etc., soup, or broth, may be given, with the idea of stimulating the gastric digestion of proteins. Eggs may be given, raw or lightly cooked. Carbohydrates and fat should not predominate in the diet, but some must be given. Pancreatic extracts, extract of malt or takadiastase, may be given to assist digestion of farinaceous foods. Benger's and other predigested foods can be given when vomiting has subsided. Functional disorders may be much improved, but pancreatitis runs an unfavourable course. If the patient survives the initial period, and the disease subsides into a subacute or chronic form, the return to ordinary diet must be gradual, and should be regulated by the degree of glycosuria, power of digestion, and ability to assimilate food. It may be necessary to put the patient on the diet for severe diabetes.

The Thyroid Gland.—Removal of the thyroid for goitre produces cachexia strumipriva, in which there is a diminution of physical energy, dulness of intellect, and apathy. This condition is almost identical with cretinism due to defective development (*athyroidea*), and a similar condition occurs in myxœdema. The thyroid gland has a marked influence on carbohydrate metabolism through its control over the pancreas, and recent experiments have shown that protein metabolism is controlled through its influence on the liver, and calcium metabolism through the parathyroids.

Marasmus in Children.—Wasting of the body is due to various causes, but in many cases it is associated with inactivity of the thyroid gland. The children require careful dieting, and should

be given those foods which stimulate the thyroid—*e.g.*, oatmeal, minced liver, raw meat, and raw-meat juice. Oatmeal markedly influences the functional activity of the thyroid, promotes growth of the body, and increase of weight. Raw meat, liver, raw-meat juice, and meat extracts containing vitamines (*q.v.*) have a similar effect. Milk and eggs, although exceedingly valuable foods, and absolutely necessary for children, do not stimulate the thyroid so much. A diet of bread, milk, and eggs was found to reduce the activity of the thyroid in animals, but is almost neutral. Whole wheatmeal and germ bread stimulate growth and nutrition much more than white bread. Cod-liver oil is extremely valuable; the small amount of iodine may have an influence on the gland.

Rickets.—This disease is especially common in children fed on farinaceous foods deficient in fat and protein. But there is something more. Scurvy-rickets is associated with a want of freshness in the food. The concentration of foods—*e.g.*, in condensed milk and farinaceous foods—often disturbs the relation of the mineral constituents. Babes at the breast do not develop rickets because the milk is fresh; it contains ions of the metals and various vitamines. These vitamines are destroyed by boiling or condensing milk, and the ions are reduced to ordinary salts. Fresh vegetables are chiefly valuable because they contain ionized substances. The nutritive disturbances in rickets are accompanied by changes in the bones. It has been suggested that these changes have an inflammatory origin, possibly due to lactic acid absorbed from the alimentary canal. Whether this be so or not, it is certain there is something interfering with the metabolism of calcium. Recent observations show an association between rickets and insufficiency of the parathyroids. It would, however, be premature to ascribe all cases of rickets to disease of the thyroid and its accessory glands, for similar changes to those occurring in rickets have been observed in animals after the removal of the thymus as well as the parathyroids.

The food of a rickety child should be in accordance with these findings. Foods rich in lime, especially fresh milk, should be given. Lactophosphate or hypophosphate of lime and lime-water would be useful, but it is useless to give the child more lime than is contained in a proper daily allowance of human or cow's milk. Milk, cream, eggs, and cod-liver oil have ever been found valuable in the treatment of rickets and scurvy-rickets. Raw-meat juice, scraped raw meat, and meat extracts are beneficial. Whether the disease is due to thyroid insufficiency or irritation of the bones by lactic acid, it would be a correct procedure to limit the consumption of carbohydrates. All fats are beneficial. Cheadle says the food should consist of one-third carbohydrate, one-third protein, and a quarter fat. Oatmeal is probably the best carbohydrate food, seeing that it stimulates the activity of the thyroid. Oatmeal-water should not be regarded as a mere diluent of milk for infant feeding, but as a foodstuff of special value for growing infants. In the third year of life oatmeal porridge and milk should form a staple breakfast dish for all children, and

this should be followed by dry rusks or crusty bread, which necessitate mastication and cause a flow of saliva. In gouty persons the thyroid gland probably works at high pressure; in the children of such people the nutrition is often disturbed, their urine concentrated, and their skin affected by eruptions. Oatmeal is not always beneficial to such children; they cannot always digest or assimilate it. The symptoms complained of are sometimes exaggerated by oatmeal, but this occurs less often when oatmeal and milk form the whole meal, than when the porridge is followed by egg and bacon or other rich foods. The daily use of fruit-juices (orange-juice, strawberry-juice) and fresh vegetables—*e.g.*, boiled carrot, vegetable marrow, potato cooked in the skin, baked apple, or apple sauce—is very necessary in all cases of scurvy-rickets.

Osteomalacia.—If this disease is due to insufficiency of the parathyroids it requires similar treatment to rickets and cretinism.

It has, however, been shown that the suprarenal bodies are concerned in the retention of calcium, and osteomalacia is improved by the administration of adrenalin or suprarenal extract, whereby there is caused a retention of calcium. The thyroid and adrenal glands mutually stimulate each other; therefore thyroid insufficiency implies a loss of the normal stimulant to the adrenals. There is a retention of calcium in the organism after the menopause, and osteomalacia has been cured by artificial production of the menopause by oöphorectomy; therefore it may be concluded that the ovaries influence calcium metabolism.

In osteomalacia the diet should consist largely of milk and oatmeal. An abundance of fresh meat, fowl, fish, soup, and meat extracts should also be given to nourish the body. The idea is to stimulate the thyroid gland, and through it the adrenals. At the same time, we should endeavour to avoid gastro-intestinal catarrh, bacterial fermentation, or disturbances of the liver and other organs.

Acute Thyroiditis.—This affection may occur during the course of any infectious disease, and causes pain and distress by the tension in the gland. It may affect only the isthmus, one lobe, or the whole gland. The fever diet should be prescribed; but oatmeal, meat extracts, soups, etc., should be forbidden; the gland should not be stimulated until the inflammation is subsided.

Goitre or Bronchocele.—Endemic goitre is associated in the minds of men with some impurity in the drinking-water; but the cause may be in the food, air, unhygienic surroundings, and want of sunshine. It is the custom to prescribe distilled or boiled water on the assumption that the active agent in water is destroyed by boiling. The disease occurs in people who live in calcareous or limestone districts; and, seeing that the thyroid is interested in calcium metabolism, it is proper to reduce the amount of calcium in the food. Red meat should be eaten sparingly; oatmeal and milk should not be conspicuous in the diet, but fish, fowl, tripe, and sweetbread may be ordered, with plenty of vegetables and fruit.

Exophthalmic Goitre (*Graves's or Basedow's Disease*).—This affection is due to hypersecretion by the thyroid gland (hyperthyroidism). The simple hypertrophy of the thyroid occurring in young people, especially girls, is to be regarded as a protective rather than a pathological phenomenon. But it should not be forgotten that any enlargement, however slight, carries with it the elements of the more serious Graves's disease, and it should not be dismissed as a trifling ailment. There is no need for operative treatment—this would destroy the compensatory effort and do irreparable damage. Rest, and a light nourishing but unstimulating, diet are essential.

In more severe cases also the primary requisite is rest in bed. The observation that oatmeal and liver strongly stimulate, animal foods in general moderately stimulate, and a diet of milk, eggs. bread-and-butter, biscuits, etc., only slightly stimulate, the thyroid glands, shows the way to the dietetic treatment of exophthalmic goitre. Oatmeal, liver, and excess of animal foods must be avoided; butcher's meat, oysters, and lobster should be forbidden. But the food must be good, light, and nourishing. Once a day the patient may have a moderate helping of fish or fowl (domestic fowl, pheasant, partridge, quail, pigeon, etc.), with potatoes, vegetables, and fresh fruit. Eggs, milk, milk puddings, custard, junket, jelly, bread-and-butter, and bacon or fat ham will complete the dietary. Fresh fruit and salads are advantageous; the amount should be regulated by their action on the bowels. Tea and coffee, owing to their well-known tendency to affect the sympathetic system and cause tachycardia, tremors, and other nervous symptoms, should only be taken in the strictest moderation. These patients are better without any alcohol, but a little good red wine may be allowed if any is considered desirable. Tobacco should be forbidden.

Hyperfunction of the thyroid glands leads to inhibition of the pancreas, and may cause indigestion. On the contrary, any measure which stimulates the pancreas would reduce thyroid activity. Especial care should be taken to prevent gastric and hepatic disturbances. Indigestible foods—ices, cakes, sweets, confectionery, nuts, pickles, etc. — must be avoided. If gastric catarrh supervenes, the diet ought to consist chiefly of milk and farinaceous foods—tapioca, sago, rice, and arrowroot. These will not irritate the stomach or stimulate the thyroid. When the heart is weak, and when the stomach recovers tone after catarrh, allow some pounded chicken, fish, or poached eggs; but the milk should be continued until the gland recovers its ability to metabolize iodine. The milk of thyroidectomized animals is beneficial; very good results have been obtained from its use. Goebel says such milk does not contain iodine, because the organ which excretes it has been removed. Other foods containing a recognizable amount of iodine (see p. 490) may advantageously be removed from the diet, while those containing arsenic—*e.g.*, eggs—might be prescribed.

Iodine in Plants.—Potatoes, carrots, endive, parsley, *nil;* cucumber 0·012, kidney beans 0·013, pumpkin 0·017, spinach 0·021, sorrel 0·047, melon 0·060, tomatoes 0·070, green peas 0·084, lettuce 0·096, beans 0·140, chervil 0·140, beetroot 0·140, radish 0·160, turnip 0·240, French beans 0·320, milligrammes per kilo. **Iodine in fish :** Gudgeon 0·1, ray and skate 0·2, mackerel, whiting and pike 0·3, sardines, herring, carp, and mullet 0·6, shrimps 0·7, periwinkle 0·75, sole, eel, and herring roe 0·8, coal-fish 0·9, cod, roach, bream, ling, and gurnard 1·2, oysters 1·3, salmon 1·4, milligrammes per kilo.

Lacto-Vegetarian Diet may be useful. It should consist of milk, bread-and-butter, puddings, fresh vegetables and uncooked fruit, and a few nuts. One egg may be allowed at breakfast-time. But oatmeal, germ bread, entire wheat bread, asparagus, spinach, peas, beans, and lentils should all be forbidden.

Thymus Feeding has been established as a " cure " for hyperthyroidism. It is significant that exophthalmic goitre is rare in children, and that so long as the thymus remains, hyperthyroidism never occurs ; while the occurrence of exophthalmic goitre in young adults, after the complete atrophy of the thymus, suggests that the disease is due in part to the removal of some restraining influence which the thymus held over that gland. The prescription of ¼ ounce daily of the fresh thymus (throat sweetbread) of the lamb for a period of three or four months has been found to diminish the prominence of the eyeballs, and tachycardia, but it had no influence on the goitre and muscular tremors.

Rest of the body diminishes nervous excitability, but absolute rest in bed is only necessary in severe cases. Mineral water containing phosphate of soda, 15 to 30 grains twice a day, is useful; and waters containing iron and arsenic are beneficial. Prolonged residence at the seaside—Brighton, Folkestone, Westgate, Biarritz—is useful in some cases, and at a moderate elevation in the Alps for others, but a great elevation like Davos is not suitable. Country life is suitable to those who cannot afford a sea or mountain climate. Any excess of exercise ought to be forbidden.

Myxœdema and Sporadic Cretinism.—The foods known to have a stimulating effect on the thyroid ought to be prescribed—*e.g.*, oatmeal, liver, and all animal foods. All foods known to contain iodine should be given. Foods known to have a sedative effect on the thyroid should be avoided. Milk is almost neutral, and should be considered an essential food, especially for children. Adults should have an abundant, plain, simple, and nutritive diet, consisting of oatmeal, liver, fresh meat, meat extracts, eggs, fish, and fresh vegetables. Potatoes, sugar, bread, cakes, and other carbohydrate foods should occupy a smaller place than usual in the diet. All foods containing iodine and arsenic are good. Everything should be done to avoid indigestion and alimentary toxæmia, which would throw extra work on the thyroid gland. If the patient presents signs of pancreatic deficiency, such as insomnia, persistent headache, and constipation, the use of pancreatic extracts may be beneficial.

Thyroid extract relieves the symptoms of myxœdema in many cases; but it is possible to stimulate the thyroid too much by this means, and thereby exaggerate the fatigue of the gland and bring about a worse condition of the patient. The combined thyroid proteins of the sheep, with their abundance of globulin (colloid), have been found free from this disadvantage.

The Thymus Gland.—The thymus appears to have only a temporary use in the organism. It is most active soon after birth, attaining its maximum at two years, after which it gradually atrophies, and disappears after puberty. It is associated with the thyroid, for experiments have shown that when the thymus is removed, less thyroid suffices. The thymus is of importance in the nitrogenous and calcium metabolism of children. There is a deficiency of thymus secretion in marasmus, wasting, deficiency of growth, rickets, and osteomalacia. The internal secretion of the thymus neutralizes some element of the thyroid secretion. In the absence of thymus, the thyroid gland does not have to work at such high pressure, in consequence of which there is a diminished retention of calcium, phosphorus and nitrogen. In these diseases, therefore, it is the thyroid gland which requires stimulation; clinical experience has shown the necessity for prescribing oatmeal and milk, meat-juice, raw minced liver, scraped raw meat, meat extracts, germ bread, wholemeal bread, and other foods which stimulate the thyroid, and to restrict farinaceous foods. The administration of thyroid extract and raw thymus gland is beneficial.

Excess of Thymus Gland has been found in cases of obesity in children, laryngismus stridulus, paroxysmal dyspnœa (thymus asthma), adenoids, general enlargement of the lymphatic glands, status lymphaticus, myasthenia gravis, exophthalmic goitre, acute leukæmia, and sudden death. In most of the diseases named experience has taught that a long course of milk diet, eggs, farinaceous foods, and vegetables, is beneficial to the patient. The thymus and thyroid are closely associated in their functions. The foods which make little or no demand on the thyroid, or do not stimulate it, will soothe the thymus or check its excessive activity, and under the joint influence of these glands the metabolism of calcium, phosphorus, and nitrogen will be diminished. There are, however, some cases where the excessive thymus secretion neutralizes the thyroid secretion so completely that the metabolism of carbon is interfered with. In these cases thyroid extract, and those foods which stimulate thyroid activity, should be given.

The Spleen and Lymphatic Glands.

The lymphatic glands are the seat of interchanges between the blood and lymph. Leucocytes multiply in their follicles; leucocytosis follows every meal, and is increased or diminished by circumstances. It is probable that these glands elaborate some substance

useful in metabolism, or destroy materials deleterious to the organism. The part taken in metabolism by the spleen is unsettled, but it is associated with the metabolism of iron, and the richness of spleen in extractives indicates the importance of the organ in dealing with nitrogenous bodies, and particularly with the destruction of red blood-cells. That the spleen is not essential to life is shown by the fact that men and animals do not die when the organ is removed; but splenectomy is followed by progressive loss of flesh, anæmia, diminution of the red and increase of the white blood-corpuscles, permanent enlargement of the lymphatic glands, and pains in the long bones, indicating compensatory changes in the marrow.

Hodgkin's Disease (*Lymphadenoma, Pseudo-leukæmia, and Splenic Anæmia*).—These diseases are believed by many writers to be due to a chronic toxæmia originating in the spleen, the anæmia being caused by hæmolysis by a toxin originating in the spleen or elsewhere. *Mycosis fungoides* is said by Ziegler to be a special development of Hodgkin's disease, and he believes both to be due to a micro-organism which has escaped detection.

Our knowledge of these diseases offers very little to indicate the kind of diet which would affect their course. Besides saying that the food should be light, nourishing, and digestible, there is little to add. All foods containing iron, arsenic, and iodine may be prescribed—the former to assist in the provision of material for blood-making, the latter to stimulate the blood-making organs. Ox-bone marrow, fresh or in tabloid form, and its preparations—*e.g.*, Virol—thymus gland and its extract, spleen and its extracts, will be useful. One or two ounces of fresh bone marrow should be eaten daily. Spleen can be taken raw by pounding it, and giving it in jelly, extract of meat, or extract of malt. Thymus gland (throat sweet-bread) can be given in the same way. The remainder of the food should be similar to that given for anæmia (*q.v.*). The inorganic calx sulphurata has been beneficially prescribed for this disease. Bearing this in mind, we may also prescribe foods containing the organic compounds of sulphur—*e.g.*, cabbage, spinach, asparagus, onions, garlic, chives, mustard and cress, watercress, and horse-radish. If these substances do not upset the alimentary organs, they may stimulate the metabolic functions of all the glands, and improve the general condition. The sulphurous waters of Harrogate, Pitkeathly, and Kreuznach, and the iodine waters of Woodhall Spa and other places may be beneficial. The injection of impure thyroid globulin has in some individuals proved more efficacious than iron or arsenic in promoting the manufacture of red blood-cells.

Addison's Disease.

The chromaffin system, including the adrenal and accessory adrenal bodies, are of importance in metabolism. They exert a

marked influence on nutrition. They also keep up the cardiac and vascular tone by their influence on all involuntary muscular fibres. They promote the retention of calcium. The adrenal and thyroid glands mutually stimulate each other, but the adrenals are somewhat inhibited by the pancreas. Hyperglycæmia and glycosuria occur when the pancreas is removed, or when the blood contains an excess of adrenalin. In Addison's disease there is hypofunction of the adrenals and the special symptoms of the disease. The absence of those symptoms, when the suprarenal capsules are diseased, is due to compensatory enlargement of the accessory adrenal bodies.

The treatment of Addison's disease is unsatisfactory. The tissues waste rapidly. The food, therefore, must be nourishing and abundant, but it should be light and easily digested. The irritation of the alimentary mucosa may require abstinence from food occasionally. If there is any vomiting, some iced champagne, albumin-water, lime-water and milk, peptonized milk, Brand's essence, or Valentine's beef-juice, should be given in very small doses until it subsides. If there be diarrhœa, the patient should abstain from soup, broth, yolk of eggs, and extracts of meat; the diet should consist of arrowroot and milk, cornflour and milk, Benger's food, a teaspoonful or two of scraped meat, pounded chicken or fish, and albumin-water as a beverage. If diarrhœa is a constant feature, the patient should be put on a diet for chronic diarrhœa or intestinal catarrh (pp. 336, 356). In other cases the regular diet for chronic catarrh of the stomach and bowels is applicable to Addison's disease. Alcohol may be necessary when syncope threatens. If the patient is markedly tubercular, the diet for tuberculosis should be in general use; but it will be necessary to watch for gastro-intestinal troubles, and order the diet suitable for them.

Acromegaly.

The pathology of this disease is unsettled. In many cases it is associated with adenoma of the pituitary body, and chiefly of the anterior lobe, which presses on the posterior lobe and disturbs its functions. The anterior lobe of the pituitary body influences the growth of bones, development of stature, and form of the body; the posterior lobe exercises a powerful influence over the vasomotor system (it regulates the blood-pressure), and over the metabolism of carbohydrates. Removal of the posterior lobe, or a diminution of its secretion from any cause, enhances the power of storing carbohydrate, but depreciates the power of using it. In the early stages of acromegaly there is hyperpituitarism; the whole gland is affected. The increased function of the anterior lobe causes skeletal changes; the increased function of the posterior lobe leads to hyperglycæmia, polydipsia, polyuria, and glycosuria. A frequent examination of the urine, therefore, is necessary. The

patient should be dieted as in the same way as for diabetes (*q.v.*), and the metabolism of carbohydrates should be aided by pancreatic extracts. By-and-by there will be hypopituitarism due to loss of the secretion of the posterior lobe, leading to obesity and fatty changes in the liver or other glands. Now the tolerance of carbohydrates is increased, but their oxidation is defective. The diet should now consist of ordinary mixed food; but the oxidative processes should be assisted by the administration of thyroid and pituitary extracts until glycosuria is produced.

CHAPTER XVII

DISEASES OF THE SKIN

Acute Diseases of the skin should have the same dietetic treatment as other inflammatory diseases (*fever diet*). These include acute eczema, erythema, erysipelas, lichen tropicus, urticaria, roseola, etc.

Chronic Diseases of the Skin usually require the same treatment as indigestion and alimentary toxæmia. A few remarks on special diseases are appended:

Hyperidrosis.—Seek for the causes of debility, and treat them. If it affects chiefly the hands and feet, look for orthostatic or intermittent albuminuria, or spermatorrhœa. The food should be nourishing, but *hot* milk, oatmeal, and excess of carbohydrates, onions, horseradish, etc., should be avoided. **Anidrosis** requires the opposite treatment: abundance of warm foods, hot milk, oatmeal, plenty of carbohydrates, onions, garlic, horseradish, and all substances containing sulphur. The usual means of stimulating the skin should be adopted.

Seborrhœa requires a tonic regimen: foods containing iron for the chlorotic, arsenic for the anæmic, and a course of cod-liver oil for the strumous. Indigestion and alimentary toxæmia should be looked for and treated. If the disease is associated with hyperidrosis, an excess of carbohydrates must be avoided.

Acne Vulgaris requires a tonic regimen. The food should be nutritious, but excess of carbohydrates must be avoided, especially sugar, and sweet foods; beer, and alcohol should be forbidden. The condition of the thyroid, ovaries, and other glands should be investigated.

Acne Rosacea.—Particular care must be taken to prevent or cure existing indigestion, constipation, hæmorrhoids, and menstrual troubles. The patient should be impressed with the necessity for closely observing the effects of all kinds of food on the skin. Ordinary light food is usually sufficient. Hot meals do not suit the complaint. Fat is sometimes injurious. Irritating foods, alcohol, and condiments should be prohibited as a rule; but many patients are improved by eating cayenne pepper with meat and fish. China tea is better than other kinds. Milton says the patient should not abstain from tea; it is one of the best stimulants for the depressed organism. A moderate amount of light claret or Burgundy is

sometimes beneficial. Men who have been much addicted to alcohol may have a little good cognac and water.

Lichen.—The chronic form requires light and unstimulating diet. High feeding is not beneficial, but the diet should tend to improve the nutrition and standard of health. The foods likely to cause indigestion must be forbidden. Beer, ale, and stout should be avoided; but a small quantity of hock, Sauterne, Saumur, and white Val de Peñas would be beneficial. Foods containing iron, arsenic, and iodine are suitable if they do not upset digestion. Cod-liver oil is beneficial in many cases.

Eczema.—The chronic disease requires good, plain, nourishing food—*e.g.*, fat bacon and egg for breakfast, fat meat and plenty of vegetables for dinner, and a simple pudding or other light food for supper—that is, the diet should be of the ordinary kind, but moderate in quantity, and free from spices and condiments. Excessive eating is injurious. The chief thing is to avoid indigestion and alimentary toxæmia. It should never be forgotten that the skin trouble will be aggravated by irritation of the gastric mucosa. Therefore meat, fowl, fish, and eggs must be quite fresh and free from taint or high-keeping. Tinned and potted meat must not be consumed, neither should pork, veal, sausage, shellfish, salted meat, or fish. A small amount of fat ham or bacon for breakfast is permissible, but the persistent use of salt foods for all meals is highly injurious. Cheese, especially very ripe cheese, is bad. Starchy and sweet foods require careful consideration. Bread must be good, and either white or wholemeal bread; bran bread must not be eaten. Oatmeal should be avoided. When there is any gastro-intestinal catarrh, starchy foods should be taken sparingly. Reflex irritation of the skin follows irritation of the mucosa by organic acids. Potatoes are usually a valuable addition to the diet, and all well-cooked vegetables are useful foods. Salads, such as lettuce, watercress, and celery and fresh fruit, are good in most cases. Sugar is sometimes injurious, and cessation from its use is often beneficial. Fat is not injurious, but a great quantity might cause hypochlorhydria and lead to organic acidity of the stomach. Sour-milk treatment is sometimes beneficial.

Tea and coffee are excellent beverages when not taken to excess, but alcohol is injurious in most cases. A small amount of red wine —Val de Peñas, port, or claret—may do good in cold weather. Malt liquors should be forbidden.

Psoriasis.—Every effort should be made to improve the general health. The condition of malassimilation and debility must be attacked. If the health is apparently good, the diet should be the same as in chronic eczema—that is, a light ordinary diet, free from spices and condiments, and indigestible articles. Forbid oatmeal, new bread, pastry, dressed dishes, pickles, strong tea and coffee, wine, and malt liquors. Potatoes are sometimes injurious. Salisbury diet is beneficial in some, and a milk diet in other cases. Vegetarian diet is useful when there is a disordered metabolism, or

the urine is acid and has a high specific gravity. A sedentary occupation should be changed for a more active life—*e.g.*, removal from town to country, farm life, or other useful occupation. Sea air is prejudicial to psoriasis, but a course of sulphurous waters and baths is beneficial.

Ichthyosis requires similar dietary to chronic eczema or psoriasis.

Chronic erythema and **urticaria** as a rule require the same dietary as chronic eczema; but when the patient is exhausted by the disease, the food should be more stimulating. Good rich soup, oysters, and port wine are then beneficial. When the disease is due to alimentary toxæmia, the dietary for that disorder should be prescribed.

Lupus.—The tubercular condition which underlies this affection demands the dietary for tuberculosis. The food should be light and restorative rather than stimulating. Heating foods cause the lupous patches to feel stiffer. But some cases do better when the food is well seasoned with condiments, and fresh vegetables containing organic sulphur are consumed. In these cases all vegetables of the *Cruciferæ* are beneficial, if they do not upset the alimentary organs, and coffee is preferable to tea. When there is marked debility, the liberal use of light wine—Chablis or Sauterne—is beneficial, but fiery wines—*e.g.*, brandied port and sherry—and malt liquors are injurious.

Purpura and Scurvy.—The food should be light and nutritious. Fresh milk should be taken unboiled, so that the greatest amount of enzymes, lecithin, and vitamine may be obtained. Raw-meat juice, scraped meat, meat broths, soup, eggs, custard, and jellies are valuable. The diet must also contain mashed fresh potatoes (boiled in the skin), carrots, onions, cabbage, and apples. If the gums are not too sore to permit mastication, the green salads, onions, lettuce, dandelion-leaves, and fresh fruits are exceedingly valuable. Lime-juice and lemon-juice hold a high rank as curative agents. The chapter on Vitamines should be read.

Pellagra.—The diet must be carefully considered. There must be a normal adjustment of the proteins, fats, carbohydrates, and energy. An excess of fat would exaggerate diarrhœa in some cases; in others it would prevent constipation. Excess of carbohydrates would lead to fermentation, and intensify the gastro-intestinal catarrh. A meat diet has been found beneficial in some cases, especially where animal food has previously been deficient. Zomotherapy has also been beneficial. The main treatment, however, consists in the supply of good nourishment, with a slight preponderance of animal food—meat, milk, eggs, poultry, fish, fresh fruit, and vegetables—and enough bread, potatoes, and cereal products to make up a sufficiency. In this way, whether the disease is due to deficiency of vitamines (*q.v.*), to toxæmia, or chronic infection, the body will be nourished, metabolism provoked, and the formation of antibodies encouraged. Whether the disease is due to eating maize or not, common sense suggests the exclusion of

this suspected food; but some physicians find coarse maize-meal containing the cuticle is curative. When gastro-intestinal catarrh is a marked feature, the patient should be dieted in the same way as other persons suffering from diarrhœa, chronic intestinal catarrh, etc. The condition of chronic constipation also demands the ordinary diet for that complaint. Alcohol is unnecessary as a rule —it may be prejudicial—but koumiss, kephir, milk punch, some good red wine, well-diluted brandy or whisky, may occasionally be necessary.

CHAPTER XVIII

DISEASES OF THE BLOOD AND CIRCULATORY ORGANS

Anæmia.—The *treatment* of the anæmias may be taken together. One of the principal elements required for the formation of hæmoglobin is iron. The body of a human being contains very little of this element. The blood of an adult contains only about 3 grammes (Halliburton), and there is a small amount in the other fluids of the body, and the liver and spleen. The normal percentage of iron in liver washed free from blood is 0·10 (Bemmelen).[1] The proportion is greatest in the liver of new-born animals; in leukæmia it may be reduced to 0·078 (Hunter), or even 0·010 (Halliburton). It is probable the liver is a place of storage for iron, especially in young animals; but this function persists throughout life. In pernicious anæmia the liver is exceedingly rich in iron, owing to excessive destruction of red blood-cells. In fact, Biernacki proved that in chlorosis and some other forms of anæmia the total amount of iron in the body is normal or more than normal. However, it has been shown that iron is one of the essential elements of the food. If animals are deprived of it, they waste. Experiments show, if the food contains no iron, animals lose 40 per cent. of the iron of their body in three weeks.[2] Stockmann[3] estimated the average amount of iron in the ordinary mixed food of human beings is about 9 or 10 milligrammes ($\frac{1}{6}$ grain) a day; but the food eaten by chlorotic subjects often contains as little as 3 milligrammes. Herter arrived at the same conclusions.

The almost constant prescription of iron as a remedy for anæmia necessitates a consideration of its value. Iron salts have been used for ages, but doubt has been cast upon their usefulness. There is an absence of direct evidence to show that blood-cells are able to assimilate inorganic iron. Bunge, Mörner,[4] and others assert that inorganic iron is not absorbed from the bowels, but it is beneficial by removing sulphuretted hydrogen from the alimentary canal and checking the putrefaction which destroys organic iron-bearing substances. Von Noorden, Stockmann,[5] and others, on the contrary, assert that inorganic salts of iron are absorbed from the bowels.

[1] *Zeit. Phys. Chem.*, vii. 497.
[2] Hall, Du Bois Raymond's *Archiv*, 1896, 49.
[3] *Jour. Physiol.*, 1895, 484.
[4] *Zeit. Physiol. Chem.*, xviii. 13.
[5] *Brit. Med. Jour.*, 1893, i. 881, 942.

In any case, there is no doubt that various conditions dependent on the altered state of the blood are improved by them, and much benefit is derived from their general tonic influence. There is, however, a method of solving the problem, and that is by estimating the iron in the fæces. This was adopted by Munro of Cheltenham,[1] who experimented on typical cases of chlorosis with freshly prepared Blaud's pills and ammonio-citrate of iron. Before giving iron he placed every patient on Schmidt's diet for a week, when the fresh fæces contained an average of 0·0022 gramme of iron, and the dried fæces 0·0089 gramme daily. The results obtained were as follows:

INORGANIC PREPARATIONS OF IRON.

	Blaud's Pills.		Ammonio-Citrate of Iron.	
	Before Treatment.	After One Month's Treatment.	Before Treatment.	After One Month's Treatment.
Red corpuscles	3,800,000	3,848,000	3,808,000	3,844,000
	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Hæmoglobin	70·0	72·0	70·0	75·0
Iron in fæces: (*a*) Fresh . .	·0031	·075	·0016	·163
(*b*) Dried	·010	·218	·0090	·815

Iron is absorbed by the mucous membranes of the duodenum and jejunum, and passes by way of the lymph channels to the blood, and is deposited in the spleen and liver. There it is temporarily stored. Iron is excreted from the body, one-tenth by the kidneys and nine-tenths by the mucous membrane of the colon and cæcum. The excessive amount of iron in the fæces of patients taking inorganic salts shows that the organism cannot make immediate use of large quantities; but the increase of hæmoglobin and red corpuscles prove that such salts are not inert, although it is probable that the ordinary doses of iron taken as medicine are excessive.

The normal supply of iron to the body consists of organic substances, such as hæmoglobin, and combinations of nucleo-albumin in vegetables, which have been called *hæmatogens*. These nucleo-albumins take up iron circulating in the sap of plants, and convert it into absorbable and assimilable material. Although the inorganic combinations are badly absorbed and but little used, it seems certain that the organic forms of iron which occur in meat (muscle), fish, and especially liver, spleen, bone-marrow, and other animal and vegetable substances, are readily assimilated and easily used for the manufacture of hæmoglobin. This point was also elucidated

[1] *Brit. Med. Jour.*, 1911, ii. 105.

by Munro,[1] who experimented with commercial organic preparations. He found as follows:

ORGANIC PREPARATIONS OF IRON.

	Preparation A.		Preparation B.	
	Before Treatment.	After One Month's Treatment.	Before Treatment.	After One Month's Treatment.
Red blood-corpuscles ..	3,400,000	4,272,000	3,042,000	3,820,000
	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Hæmoglobin	70·0	88·0	45·0	76·0
Iron in fæces: (*a*) Fresh ..	·0028	·031	·0020	·014
(*b*) Dry	·0097	·112	·0082	·048

The difference in the results obtained from organic and inorganic compounds is very marked. When inorganic salts are used, a very large proportion is unabsorbed and voided in the fæces; when organic preparations are given, a comparatively small amount escapes in the fæces, and the proportion of hæmoglobin in the blood is much greater. Iron plays an important part in the formation of chlorophyll in plants, and its presence in all green vegetables is worthy of note. Iron in plants is not merely present as a pigment; it occurs in combination with under proteins in parts which possess no chlorophyll. Moreover, its importance in the human economy suggests the use of all foodstuffs which contain it.

IRON IN FOODS.

Animal Foods:	Per Cent.	*Vegetable Foods (continued):*	Per Cent.
Blood of pig ..	·0634	Lentils ..	·0083
Blood of ox ..	·0375	Haricot beans ..	·0074
Beef ..	·0200	Wheat ..	·0084
Veal ..	·0270	Wheaten bread ..	·0048
Egg-white ..	·0260	Cabbage ..	·0039
Egg-yolk ..	·0420	Maize ..	·0036
Whole egg ..	·0057	Peas ..	·0024
Milk ..	·0030	Apples ..	·0020
Fish ..	·0015	Strawberries ..	·0024
		Potatoes ..	·0016
Vegetable Foods:		Rice ..	·0015
		Carrots ..	·0009
Spinach ..	·0450	Burgundy ..	·0019
Oats ..	·0131	Beer ..	·0004

According to Johnston,[2] the ash of potatoes and peas contains 0·85 per cent. of oxide of iron, oats 0·65, maize and beans 0·40, carrots 0·32, cabbage 0·17, barley 0·16, and wheat a trace. Ac-

[1] *Loc. cit.* [2] "Agricultural Chemistry."

cording to Halliburton, the ash of blood contains 8·37 per cent. of oxide of iron, liver 2·74, spleen 7·28, lungs 3·2, muscle 0·057, serum 0·26, and milk 0·10.

Arsenic is a stimulant to the blood-making organs. Its value in this respect has been well proved, and, like iron, the organic combinations are more easily assimilated, and therefore more useful, than inorganic preparations. Until quite recently it was considered that arsenic is a constituent of very few tissues, but as the result of numerous experiments Bertrand[1] found it to be a constant constituent of living cells, like carbon, sulphur, and phosphorus; that it exists in minute traces in all animals and vegetables, and is essential for their well-being. Nevertheless, the proportion in some tissues is greater than in others. Thus, he found the amount of arsenic in a fowl's egg varied from 0·0005 to 0·005 milligramme, two-thirds being in the yolk, and one-third in the white, shell, and lining membrane.

In the treatment of anæmia, no matter what is the cause, the use of foods containing the largest proportion of iron is a scientific procedure. Hæmoglobin contains 0·4 per cent. of iron, and therefore blood, meat, and fresh-meat juice are important foods. There are various commercial preparations containing hæmoglobin, such as Bovinine and Vinsip. Milk, in other respects so valuable for the anæmic and debilitated, contains only 0·003 per cent. of iron. Therefore we must rely chiefly on meat, fish, oysters, liver, bone-marrow, spleen (" smelt "), lentils, beans, and other vegetable substances. Stockmann[2] estimated that 1 litre of milk contains 2 to 4·3, 100 grammes dried bread 0·85 to 1·0, 100 grammes dried oatmeal 3·5, 100 grammes dried beefsteak 3·9, 100 grammes yellow ox-marrow 2·5 to 4·0, and red calf-marrow 7·6 to 8·7, milligrammes of iron.

It is probable that the nucleo-albumin iron-containing substances of ordinary food are the usual and sufficient source of iron for the organism, and the inorganic iron in the food is excreted unchanged. In chlorosis there is either increased destruction or diminished formation of hæmoglobin. The theory of increased destruction is not very satisfactory; that of diminished formation is more important. Diminished formation is due to deficient function of the hæmatopoietic organs, which require stimulation. This must be done by good food, iron, and arsenic. In chlorotics the digestion and absorption are usually good, and metabolism the same as in health. Ketcher of St. Petersburg investigated the assimilation and metabolism of nitrogen in chlorotic women. The assimilation of nitrogen was normal, but the metabolism of nitrogen was 86·32 per cent.—that is, below the *mean* but not below the minimum for healthy individuals. The total quantity of nitrogen in the urine, the nitrogen of urea, the chlorides, and the phosphates, was less than normal. Lipmann-Wulf made similar investigations, and

[1] *Bull. de la Soc. Chim. de Paris*, 1904, No. 15.
[2] *Jour Physiol.*, 1895, 484.

concluded that chlorosis does not cause an abnormal change in the metabolism of protein. If there is any difference in the gastric functions, it is in the direction of hyperchlorhydria; the total acidity of the stomach is increased in 95 per cent. of cases, and free hydrochloric acid is in excess. It is important that this condition be borne in mind. Hayem[1] considered it so important that he deprived the patient of bread for four or five weeks. The diet should consist of plenty of animal food, and the first meal of the day should always contain a fair proportion of meat or milk. Raw meat or scraped meat is more easily digested than that cooked in the ordinary way; it should never be highly baked, rather underdone. Eggs, especially the yolk, are rich in iron, and should be taken freely. Oatmeal porridge or cornmeal mush, with plenty of cream or milk, is suitable. Bone-marrow should be especially recommended. Salads and all digestible fresh vegetables must be taken; when the stomach does not bear them very well they must be boiled and reduced to a purée. Any relation between alcohol and the formation of hæmoglobin or blood-cells is highly improbable; but a small amount of red wine—claret, Burgundy, or port—or some beer or stout, may be allowed because they stimulate appetite and encourage nutrition. The patient should *avoid* salt-dried meat or fish, hashed meat, clear soup or broth, vinegar, pickles, spices, lime-juice, lemons, and other substances likely to cause indigestion.

The amount of protein should be 100 to 120 grammes daily. The following sketch of a daily diet will be a sufficient indication of the food required. The meals should be small and frequent. A glass of hot milk should be taken on wakening. *Breakfast* should consist of oatmeal porridge, followed by an egg and some smoked bacon or a mutton-chop with bread-and-butter, tea or coffee with plenty of cream, and an apple or some other fresh fruit; 11 a.m., an ounce or two of raw-meat juice and port wine, or a sandwich or two of scraped meat, or a raw egg-and-milk with two or three biscuits. *Dinner:* A cupful of thickened soup, containing vegetables, underdone beef or mutton, fish, poultry, boiled green vegetables, especially spinach and potatoes, milk puddings containing eggs, fresh fruit, or cheese and salad. *Tea:* Two or three sandwiches of raw scraped meat, followed by a few strawberries, lettuce, watercress, etc.; 6 p.m., a glass of port wine and raw-meat juice. *Supper:* oatmeal porridge, fish or meat. *Bedtime:* A glass of milk.

Raw-meat juice must be carefully prepared (p. 213). If there is a doubt about its preparation and purity it would be better to prescribe Bovinine, Vinsip, and other preparations of blood.

Bone-marrow is exceedingly valuable in anæmia, particularly pernicious anæmia and leukæmia. It was first recommended by Barrs. It is important to select red marrow, and the marrow of calves is better than that of oxen. A teaspoonful should be taken three times a day; some authorities prescribe from $1\frac{1}{2}$ to 4 ounces daily, the dose being gradually increased. It should be eaten raw,

[1] *Jour. des Prat.*, 1895, 17.

between thin slices of bread, seasoned with salt and pepper. If the patient is unable to take it in this way, it can be prepared by the method of Agasse-Lafond: Take a mortar which has been carefully scalded, mix in it 6 drachms of gelatin softened by a suitable quantity of water, with 1 ounce of glycerine; in another scalded mortar mix 3 ounces of fresh red marrow with a fluid ounce of port wine. Mix the two together until they form a paste. This preparation is not disagreeable, and will not spoil the appetite. If fresh marrow cannot be obtained, the commercial products must be used.

Spleen is also useful. It is sold by butchers under the name of "smelt" or "milt." It can be used for making soup or gravy, but it would be better pounded in a mortar and eaten raw in soup, aspic, or sandwiches.

Liver, from its large proportion of iron, should be equally serviceable. Its proteins are ferruginous nucleo-proteins. When liver is minced and boiled in water most of the ferruginous protein is extracted; it has been called **ferratin,** and is sold commercially. Liver soup, made by boiling the minced liver with pot-herbs, should be often eaten. The fresh liver may be scraped and given uncooked in soup, broth, and sandwiches.

There are various hæmatogenous substances sold commercially. *Ferroglidine* is a vegetable preparation, *iron somatose* is a combination of beef peptonoids and iron; they are exceedingly useful foods.

The treatment of anæmia by limitation of fluids deserves mention. Haldane and Lorraine-Smith showed that, although the percentage of hæmoglobin in the blood is diminished, the total amount in the body is normal; the anæmia is relative, and due to an excess of plasma. Therefore Melland suggested that a dry diet would cure chlorosis by concentrating the blood. Chlorotic persons often suffer from hydræmia; their tissues are laden with water, and the reduction of water would be beneficial to them. This may be done by dry diet or salt-free diet. Many chlorotic persons have a habit of drinking large quantities of tea or water, due to a primary polydipsia. If at the same time they take an excess of salt, or if chlorides are not properly eliminated, there will be retention of water in the tissues. Chlorotic persons sometimes have puffiness of the face, œdema of the extremities, and increase of weight. Moreover, it was observed by Moraczewski that in chlorosis the excretion of chlorides is sensibly diminished. It is advisable in such cases to restrict the fluids to 1½ or 2 pints daily, and avoid the use of salt, excepting the smallest amount to flavour potatoes and vegetables. The blood may be further concentrated by using salines, whence arises the benefit derived from certain purgative waters and salts. Under this treatment there should be a reduction of body-weight, increased excretion of urine, increased firmness of body, greater freedom in respiration and movement. When iron alone fails to cure, a combination with the salt-free and dry diet often has a beneficial result.

In Pernicious Anæmia the treatment must consist of absolute rest; rest in bed being preferable, and country better than town. The diet should contain little farinaceous material, and a liberal allowance of meat, fish, fowl, rabbit, sweetbread, pheasant, partridge, tripe, etc., but especially raw meat, meat-juice, milk, junket, and eggs. If the stomach is irritable kephir or other forms of sour milk may be given for a time. If there is atony of the stomach or hyperchlorhydria, give the dietary for them. It should not be forgotten that pernicious anæmia is associated sometimes with achylia gastrica. Fenwick was the first to notice that patients who died of pernicious anæmia had a marked atrophy of the gastric mucous membrane, and he believed achylia gastrica is the cause of pernicious anæmia; but recent writers do not agree with him. The occurrence of achylia gastrica, however, necessitates the use of foods which will readily pass through the pylorus into the duodenum. Bone-marrow should be prescribed. Morgenroth found the anæmia following poisoning by cobra-lecithide can be cured by cholesterin, and the hæmolytic action of saponin can be prevented by it; and suggested the use of this as a remedy for pernicious anæmia. Guillan also says cholesterin diminishes the hæmolysins of the blood. If cholesterin is capable of acting beneficially in this disease, it would prove pernicious anæmia to be a process of hæmolysis.

The theory that hæmolysis is the cause of pernicious anæmia is not generally accepted, because there is no hæmoglobin in the serum of urine, the ailment being commonly thought due to disease of the blood-making organs. Notwithstanding these objections, Klemperer[1] tried cholesterin in the treatment of pernicious anæmia. He gave a 3 per cent. solution of cholesterin in oil, but patients did not like it, and could scarcely be induced to swallow it. Previous experiments taught him that the ingestion of milk, cream, and butter in large quantities caused an increase in the amount of cholesterin in the serum; 1 litre of cream and 200 grammes of butter correspond to 2·1 grammes of cholesterin. These substances can be made into jellies, creams, and other articles of food well known to cooks, and when combined with ordinary mixed diet, are capable of exercising a marked effect on general nutrition. To enable the patients to digest large quantities of cream and butter, Klemperer prescribed small doses of brandy and a powder, consisting of calcium carbonate and calcium phosphate. Ebstein also considers fat in various forms hastens blood-formation, and that fatty and albuminous foods should figure largely in the diet.

It should be pointed out that cholesterin is a normal constituent of all animal and vegetable cells; it is present everywhere, and is probably one of the essential foodstuffs, although we do not know the exact rôle played by it in the vital functions (see Vitamines). Milk contains 0·0318 per cent.; it is present in blood, yolk of egg, spleen, liver, and nerve tissues; in peas, beans, lentils, maize, wheat-gluten, barley-fat, almonds, peanuts, carrots, beetroots, etc.

[1] *Berl. Klin. Woch.*, December 28, 1908.

These are among the ordinary foods used in a mixed dietary for pernicious and other anæmias, and may be prescribed with the object of increasing cholesterin in the blood-serum.

In **leukæmia** the dietary should be much the same as for any severe anæmia. If the digestion is poor, raw meat, meat-juice, milk, and kephir should be given; in other cases light nourishing diet is the best. Milk and custards are beneficial; farinaceous foods should be restricted. Spirig, of Berlin, studied the assimilation of food in leukæmia in a patient whose blood contained 1,700,000 red and 137,500 white corpuscles per cubic millimetre. A simple diet was given—meat, sausage, cheese, butter, bread, vegetables, etc. The nitrogen, fat, and carbohydrate in the food were determined, also the nitrogen in the urine, and nitrogen and fat in the fæces. He found the assimilation of nitrogen and fat was not so good as in healthy persons. The organism gained nitrogen, which he considered to be in accord with Von Noorden's theory that leukæmia is not a toxigenic protoplasmic disturbing disease. Burghinski shows that the inhalation of 60 litres of oxygen per day considerably increased the metabolism of nitrogen in leukæmia, especially the proportion of uric acid to urea. The use of X rays, as suggested by Senn of Chicago, has been found advantageous in both myelogenous and lymphatic leukæmia, and the administration of arsenic and iodides has proved of value. The use of mineral waters, such as Bourboule, Krueznach, Salins des Bains, Salies-de-Béarn, etc., has been found beneficial.

Plethora consists of general hyperæmia or total excess of the blood. It occurs when the blood-making organs are unduly active, or when the formation of blood is in advance of the normal destruction of the same. It manifests itself by a florid complexion, full colour of the mucous membranes, and overfulness of the capillaries and veins throughout the body, but particularly in the portal area. The excess of blood is used to a great extent in the formation of fat, which accumulates in the subcutaneous tissues and around the viscera. Overfulness of the portal vessels may lead to chronic hyperæmia of the liver, corpulency, and other diseases previously discussed.

The *Treatment* consists in reduction of the total diet, particularly excess of meat and other protein foods. The condition would readily be met by reduction of the food to two meals a day, about 6 ounces of solid food each time, besides vegetables and fruit. Beer, ale, stout, and excess of alcohol in other forms should be stopped. Skim-milk dietary, whey, buttermilk, and similar low diets are useful. Several of the diets given for the treatment of obesity might be employed, and a course of treatment at Harrogate or some other spa would be advantageous.

Arterio-Sclerosis.—This disease is often, but not always, associated with chronic renal disease. A common factor in its production is a persistently high arterial tension, but this is not constant; some cases occur in which the tension is abnormally low. Huchard

divided the disease into three stages: (1) Presclerosis or arterial stage; (2) cardio-arterial stage; (3) mitro-arterial stage. He considered the disease "begins by intoxication, continues by intoxication, and ends by intoxication." The toxæmia is usually intestinal in origin—*alimentary toxæmia*—due to dietetic errors or excesses and the absorption of toxins, which the organs are unable to destroy or excrete. It frequently arises through hepatic insufficiency or failure of the liver to reduce toxins to less noxious substances. Huchard said: "The origin of the disease is alimentary, the lesion vascular, but the danger is renal." Experimental work supports these views, but not entirely. Dunin of Varsovia got negative results in animals fed for months with substances supposed to cause this disease. It would be surprising if the results were all positively in favour of toxæmia, for arterio-sclerosis of alimentary origin takes many years to develop. But it has been shown conclusively that the total amount of food, and especially the amount of protein consumed, has a direct influence on the blood-pressure.

Diet.—The amount of food taken by a person with arterio-sclerosis, presclerosis, or hyperpiesis, should be somewhat less than an active person of the same age. If the patient has been a large eater, it may be necessary to cut the supply down to one-half he has been accustomed to take. The food should be less concentrated than that from a rich man's table. The total calorie value should be reduced by cutting out fat meat, rich or greasy foods, excess of butter, cream, cakes, puddings containing eggs, sugar, thick soup, and alcohol. The stout, obese person must cut down all foods alike (see Obesity); the gouty person will probably be benefited by reducing the proteins; and the thin person, who perhaps metabolizes carbohydrates badly, should reduce his allowance of sugar, starch, etc. A few general rules may be useful.

(1) The food should be as free as possible from bacteria; (2) it should not favour bacterial action; (3) the quantity should be moderate, especially the animal foods; (4) the patient must renounce tobacco, or take only an occasional pipe; (5) drink water between meals, to the extent of three pints a day; (6) use little alcohol; (7) avoid excitement, hurry, worry, and anxiety; go slow in all the actions of life; (8) wear woollen underclothing; (9) take daily exercise in the open air; (10) rise early, go to bed early.

It is impossible to frame a diet suitable for all cases. Every food should only be added to the list after experimental observations. No article is suitable which increases arterial pressure. In many cases the meals must be small and frequent, so that the stomach is not overburdened or the heart embarrassed. As a general rule it is unnecessary to exclude meat entirely; a small helping may be taken with the midday meal. Milk should be taken to bring up the proteins to 60 or 70 grammes, with fresh vegetables and fruit. An absolute milk diet should not be recommended as a permanency; it contains too much lime; but a lacto-vegetarian diet should be prescribed from time to time. The total amount of food should be such

as to satisfy hunger and prevent weakness. Tea, coffee, alcohol, and tobacco should be reduced in the same proportion as other foods. The food for each stage requires consideration.

1. *The Arterial Stage.*—The chief symptom is hypertension; and the affection is called presclerosis, hyperpiesis, etc. The symptoms are due to alimentary toxæmia, constipation, or hepatic insufficiency, and they will yield to an absolute milk diet, or lacto-vegetarian diet (milk, cereals, green vegetables, fruit, and nuts). The total food should be cut down, the proteins being reduced to 60 or 70 grammes a day. After a few weeks of this diet we may allow some fresh meat and fish, but the amount ought to be only a small helping at the midday meal. The proportion of lime in milk is an objection to its use, but this may be counterbalanced by the consumption of oatmeal, which has a decalcifying effect. The potassium in vegetables has a decided effect on the kidneys, and even on the excretion of lime. The articles on Intestinal Dyspepsia and Alimentary Toxæmia should be read in connection with arterio-sclerosis.

2. *The Cardio-Arterial Stage.*—There may be increased arterial tension, visibility and tortuosity of the arteries, accentuation of the second aortic sound, hypertrophy of the heart, and sometimes albumin and casts in the urine. We cannot cure the hypermyotrophy and thickened adventitia of the arteries, but a good deal can be done to relieve the heart and prevent the degenerative changes with which it is threatened.

The total food should be reduced, and the protein kept down to 70 grammes or less daily, as in the previous stage. The diet should be such as will relieve the tension, prevent toxæmia, and act on the kidneys. In bad cases the patient should be put to bed for a week or ten days and given an absolute milk diet, theobromin or its compounds to act on the kidneys, and alkaline waters or pure distilled water. After this period some oatmeal should be added, and in a day or two the following diet may be prescribed: Milk 2 pints, oatmeal 1½ ounces, a plateful of rice pudding, and some bread-and-butter. The future dietary must now be carefully considered. It must be a low protein diet. Very little animal food should be taken. A lacto-vegetarian diet is the best. The excess of lime in milk will be counteracted by oatmeal, vegetables, and fruit. Lemon-juice has a special value in these cases, and therefore lemon-water is a useful beverage. Very little tea and coffee should be taken, because of the tendency of caffein to increase the blood-pressure. Theobromin is a proper remedy for the disease, and therefore cocoa is beneficial. Soup made from animal substances should be forbidden, because it may contain the pressor substances of meat, and these are injurious. Meat bases, purins, extracts of meat, meat wines, are all injurious. Vegetable soup may be allowed; any vegetable may be used for this purpose except mushrooms, truffles, morels, and those containing oxalic acid. A fragrant and palatable consommé can be made by boiling together six or seven of the following vegetables in water until they are quite soft: Carrots, turnips, parsnips, onions,

leeks, garlic, celery, chervil, lettuce, mint, thyme, marjoram, savory, tarragon, bay-leaf, salsify, endive, etc. Alcohol should be avoided altogether by most patients; but if arterial pressure is not very high, a glass of old port or sherry, sugar-free champagne, or spirit and water, at one meal a day may be beneficial. Water is the best beverage; it should contain very little lime—*e.g.*, Perrier—or be distilled water—*e.g.*, Puralis, Salutaris. Alkaline waters should be prescribed when distilled or non-calcareous water cannot be obtained. Alkaline waters dilute the blood and urine, flush the tissues, wash out toxins and waste materials, and promote the action of the kidneys and skin. But there are some cases, the kidneys being diseased, where the consumption of much liquid raises the blood-pressure and burdens the heart because the kidneys are unable to excrete water in proportion to that consumed. This group of cases may be benefited by " dry diet " and the exclusion of salt from the food (pp. 229, 236). Tobacco ought to be given up by all men with arterio-sclerosis; it raises the blood-pressure. Dixon says: " A ferment is produced in the liver which counteracts the effects of nicotine." The pressor effect of nicotine in healthy persons is diminished by habit; but arterio-sclerotics are not healthy; there is hepatic insufficiency, and clinical observations support the recommendation of renunciation.

3. *The Mitro-Arterial Stage.*—The arterial resistance increases, and the heart continues to hypertrophy; in course of time the arterial resistance exceeds the cardiac power; the heart is exhausted, its cavities and orifices dilate, and the condition of dilated hypertrophy and mitral regurgitation becomes established.

Rest in bed and absolute milk diet for ten to fourteen days is the best treatment for the present condition. Milk and oatmeal or farinaceous foods should then be given for several weeks. The patient soon tires of this diet. If it is intolerable after two weeks, allow an egg at breakfast, and a fillet of plaice, sole, or whiting at another meal; vegetable marrow, spinach, cauliflower, a few kidney beans (string or snap), seakale, boiled lettuce, and a small amount of bread, or dry toast, and butter. But milk ought to be the chief food for quite a long time. When the compensation becomes re-established, we can resume the former diet; but the state of the alimentary organs should be our guide. If gastro-intestinal catarrh is very marked, the patient should be put on the diet for that complaint. But if all is going on well, we may add to the foregoing some chicken panada or minced rabbit and mashed potatoes; and gradually return to the diet for the cardio-arterial stage, or for chronic heart disease. But, above all things, it is necessary that the diet of the arterio-sclerotic should be restricted to physiological requirements. The cardiac insufficiency, fatty heart, chronic nephritis, or alimentary toxæmia, which complicates the case, demand the dietetic treatment indicated under those headings.

Milk Diet in Arterio-Sclerosis.—An exclusive milk diet acts like a charm in many cases of arterio-sclerosis by checking alimentary

toxæmia, reducing blood-pressure, and increasing diuresis. I have no hesitation in recommending it, combined with rest in bed, for periods of three or four weeks at a time, in the mitro-arterial stage of the disease.

The Lime-Poor Diet.—In 1897 Rumpf, confusing this disease with atheroma, condemned milk diet in the treatment of arterio-sclerosis on the ground that it contained too much lime, and prescribed a diet poor in lime for that disease. In 1906 Duckworth wrote: "The richness in lime salts renders abstention from milk somewhat imperative." In 1909 James Barr said: "To keep the blood-pressure low, lime salts should be eliminated from the diet, decalcifying agents used, the skin and bowels kept acting. . . . When there is cardiac failure, lime salts must be used; but when compensation is re-established, their use should be discontinued." It should be pointed out, however, that it has not been proved that the blood and tissues retain calcium during the course of arterio-sclerosis. If at any time it is desirable to give a calcium-poor diet, it can be arranged by the use of the following table:

CALCIUM IN FOODS.[1]

	Per Cent.
Basal Foods:	
Meat	·002
Eggs	·100
Cream	·147
Milk	·172
Cheese	1·240
Bread	·021
Flour: Fine	·028
Entire wheat	·037
Cornmeal	·009
Rice	·012
Pearl barley	·025
Macaroni, vermicelli	·028
Oatmeal	·078
Vegetables:	
Asparagus	·038
Beans: Dried	·215
Fresh, string	·073
Beetroot	·019
Cabbage	·058
Carrots	·077
Celery	·094
Cucumber	·028
Greens, turnip tops	·508
Lettuce	·425
Onions	·040
Parsnips	·076
Peas, dried	·137
Potatoes	·016
Sweet	·025
Pumpkins	·032
Vegetables (continued):	
Radishes	·025
Rhubarb	·060
Ruta baga (swedes)	·103
Spinach	·064
Tomato	·019
Turnips	·087
Vegetable marrow	·032
Watercress	·259
Fruits:	
Apples	·011
Apricots	·021
Bananas	·009
Blackberries	·099
Bilberries	·045
Cherries	·026
Cranberries	·021
Currants	·046
Dried	·169
Grapes	·014
Grape fruit	·029
Huckleberries	·037
Oranges	·043
Peaches	·015
Pears	·018
Pineapple	·008
Plums	·022
Raspberries	·072
Strawberries	·057
Water-melons	·018

[1] Bulletin of the Experimental Station, 45, U.S. Department of Agriculture.

The Salisbury Diet.—Meat is a decalcifying food, and a course of the Salisbury diet is beneficial in certain cases of arterio-sclerosis, especially when that disease is associated with other conditions necessitating that diet. Bertram fed a patient on meat, beer, and coffee; the calcium oxide in the food was 0·385, in urine 0·167, in fæces 0·233, grammes; and the daily loss of calcium was 0·015 gramme daily. In a second period he gave in addition 40 grammes of potassium citrate daily; the calcium oxide in food was 0·385, in urine 0·095, in fæces 0·295, and the daily loss was only 0·0029 gramme daily.

Vegetarian Diet.—According to Renvall, a supply of 0·860 gramme of calcium oxide daily is sufficient for the requirements of the body. The food usually contains more than the body requires, and some of it may be retained. Gramatchikov showed that the calcium oxide in ordinary food is 2·60 grammes, in urine 0·36, in fæces 2·00, and the body retained 0·3 gramme daily. Various circumstances interfere with calcium metabolism—*e.g.*, composition of the food, the activity of the excretory and metabolic glands. Phosphoric and citric acids increase the metabolism. A diet consisting largely of oatmeal increases the metabolism, and animals fed on oatmeal lose much calcium. The major part of the lime is excreted through the intestinal mucosa, and a comparatively small amount through the kidneys. The effects of vegetarian diet are partly due to the salts of potassium. The diet of vegetarians often contains 60 to 80 grammes of potassium chloride daily. Potassium sodium and lithium are antagonistic to calcium. They keep the calcium-protein compound in solution, and prevent its deposition. This is a point of importance in the treatment of atheroma, calcification, and arterio-sclerosis. Silicon is a constituent of cereals and other vegetables. Its importance is not clearly understood. According to Barrs, it is a decalcifying agent, and gives that property to oatmeal. Silicic acids are colloids which pass through animal membranes with difficulty; they form a large class of complex compounds. Silicates of the alkali metals are soluble in water, those of the alkaline earths in acids; but compounds of the two are insoluble in either water or acid.

The Heart.

Acute Diseases.—The treatment of pericarditis and endocarditis does not differ materially from that of the causative affection. The most common cause is acute rheumatism, and the diet should be the same as for that disease (*q.v.*). Three or four pints of milk daily in tumblerful doses, and an abundance of watery fluids, should be given. Oatmeal and other farinaceous foods may be given, lemon-water, lime-juice and water, fruit-juice and water, weak tea, whey, buttermilk, wine-whey, etc., being allowed as extras. Lime-water and hard water containing much lime are not suitable. Objection has been raised to the prescription of milk and starchy foods, owing

to the amount of lime and formation of lactic acid in the digestive tract. But the combination of oatmeal and milk is a correct procedure. Minced meat, pounded chicken, and poached eggs have been recommended; but meat contains lactic acid (p. 288). Meat broths, and soups also contain it, and fish contains protic acid. The best diet undoubtedly consists of milk, oatmeal, and farinaceous foods, until the temperature is normal. Later on bread-and-butter, poached eggs, milk puddings, fruit, and vegetables may be gradually added. Fish of the lighter kinds should be allowed when the patient can sit up, and meat when the patient can get out of bed.

In ulcerative endocarditis the patient should have milk and barley-water, milk and soda or potash water, thin oatmeal gruel, and chicken or veal broth. Creatin and xanthin, in the form of broth, extract of meat, and meat essences, are useful stimulants when the heart is failing. Broth should be made from fresh meat. If it is made from scraps of previously cooked meat it will contain an excess of lactic acid, which would be as injurious as xanthin is useful. Whipped eggs and alcohol may be given for a failing heart. The treatment of the underlying typhoid or pyæmia is more important than the cardiac symptoms.

Chronic Diseases.—Valvular diseases of the heart, when properly compensated, seldom come under the physician's notice. But when the physician knows of the existence of such disease, he should instruct his patient how to avoid indigestion, liver complaint, and alimentary toxæmia. The total food should be such as will meet the expenditure of the body—*no more;* the patient should avoid obesity. The allowance of protein should not exceed 80 grammes a day. Excess of purins and meat bases should be avoided. Heavy meals incommode the heart, flatulence embarrasses it, acidity of the stomach is injurious, and tends to catarrh of the alimentary mucosa and toxæmia. The following dietary is suitable for most cases:

Breakfast, 8 a.m.—One cup of tea or coffee; bacon and egg, or fish; bread, roll, or dry toast, 2 ounces; butter; some fresh fruit.

Dinner, 1 to 1 30 p.m.—Soup, 2 or 3 ounces; meat, fish, or fowl, cooked plainly, without stuffing or forcemeat, and eaten with little salt or condiments; bread 2 ounces, potatoes; light vegetables—*e.g.*, cauliflower, spring cabbage, spinach, asparagus, seakale, kidney beans, green peas, vegetable marrow, boiled lettuce, chard (no winter cabbage, savoy, Brussels sprouts, turnips, swedes, carrots, parsnips, beets, or salads). Simple milk puddings, custard, junket, jelly, stewed fruit, apple charlotte; cheese, 1 cubic inch if desired; fresh fruit.

Tea-Time.—A cup of tea, rusk, biscuit, dry toast (*no sweet cakes*).

Supper, 7 or 8 p.m.—A light meal of fish (sole, plaice, whiting, brill, turbot, fresh haddock, skate, or other fish, containing 2 per cent. of fat); boiled ham and tongue; cold chicken; a spoonful of potato; stale bread-and-butter; simple pudding, custard, junket, stewed fruit, plain biscuit. (No pastry, cheese, or salad.)

The consumption of foods likely to promote the formation of toxins must be avoided. Butcher's meat should only be taken once a day. Fish must be very fresh. Pork, veal, high game, entrées, stews, shellfish, lobster, crab, tinned meat, meat pastes, caviar,

foie gras, mushrooms, truffles, strong cheese, tomatoes, sorrel, etc., should be forbidden. The food should contain little salt; condiments of all kinds should be reduced to a minimum. Tea, coffee, and cocoa should be taken in strict moderation. Tobacco should not exceed 2 ounces, and may advantageously be reduced to 1 ounce a week. The allowance of alcohol should be strictly limited to 2 ounces or less per day. The total amount of fluids should be about 2 pints. An excess would distend the vessels, raise the blood-pressure, and overtax the heart; an insufficiency of fluids would tend to accumulation of waste materials in the body.

Failure of Compensation.—The cause of heart failure is weakness of its muscle. Any tendency to failure will be aggravated by indigestion, catarrh of the stomach, hepatic insufficiency or hyperæmia, alimentary toxæmia, and the causes thereof. Abuse of tea, coffee, alcohol, or tobacco have a similar effect. Among poor people a dietary of bread-and-butter and tea, too little meat, or badly cooked food causes general debility, and the heart often suffers more than other muscles. When failure is due to over-feeding or under-feeding, the heart will be improved by regulation of the diet, maintaining the protein at a proper level, and by avoiding alimentary toxæmia.

In *temporary* heart failure, indicated by dyspnœa, œdema of the ankles, etc., much improvement will follow attention to the gastro-intestinal functions and portal circulation (see Chronic Gastric and Intestinal Catarrh and Hepatic Hyperæmia). It may be necessary to order rest in bed. A milk diet will then be the proper treatment; the lime in it will increase the tone of the heart. The formation of curds may be prevented, if it seems necessary, by adding barley-water, extract of malt, Benger's or some other farinaceous food to the milk; but *citrate of soda should not be used.* After eight or ten days the amount of milk may be reduced, some meat, fish, and light puddings may be allowed, and afterwards the diet for catarrh of the stomach may be prescribed.

When compensation has broken down completely, a long rest in bed is essential. These cases are often difficult to feed. The body requires extra nourishment, but the alimentary organs are unable to deal with it. The mucosa is in a bad state, and there is usually hepatic inefficiency.. Absolute milk diet for ten days should be the rule. Under its influence the digestive and hepatic functions will improve, the tone of the heart and the action of the kidneys increase, the hydræmic plethora diminish, the accumulated nitrogenous waste be excreted, and superabundant fat used up. If vomiting occurs, and is not checked by ordinary means, it is better to desist from gastric feeding for a short time and resort to *rectal feeding* (*q.v.*). There is no doubt of the value of resting the stomach. Flatulent distension is avoided, cardiac strain relieved thereby, venous engorgement diminished, the dilatation of the heart is materially lessened, and the apex, often far displaced outwards, returns to its normal position after a week or ten days of rectal feeding. When

the gastric intolerance abates, some peptonized milk may be given by the mouth in small doses, and from this time we may gradually increase the quantity of milk until 4 or 5 pints a day are consumed.

The use of *milk* in cardiac failure is imperative. Karell prescribed skim milk, beginning with ¼ to ½ pint every three or four hours. Lenhartz prescribes a tumblerful of ordinary milk four times a day for the first five or seven days; he then adds one boiled egg and rusk or zwiebach for two to six days. After this he adds minced meat or fowl with light vegetables, and allows the patient to return to ordinary diet gradually. In my own practice I prescribe an exclusive milk diet for five or six days. After this period I order 2 pints of milk daily in doses of a teacupful. These meals are alternated every two hours with a teaspoonful or two of raw minced beef, chicken cream or panada, oysters, beef-juice, and Brand's essence of beef. After a few days the patient is allowed a small piece of steamed fish—*e.g.*, sole, plaice, or fresh haddock, a tablespoonful of mashed potato, and some Benger's or Allenbury's food. Later on some crisp dry toast, rusk, or plain biscuit (cracker), and butter can be added, and from this basis a plain wholesome diet, suitable for catarrh of the stomach, may be gradually built up; but restrictions should be put on the amount of carbohydrate foods, tea, coffee, alcohol, and tobacco.

The *dry diet* is valuable in many cases of chronic heart disease, especially when failure of compensation is associated with hydræmic plethora. The consumption of much liquid is injurious by distending the vessels, keeping them overfull, overtaxing the heart, and leading to anasarca and ascites. In the words of Oertel, the dry diet " diminishes the volume of the blood, increases its albumin, reduces the cardiac fat, strengthens the cardiac muscle, equalizes the venous and arterial blood, unloads the kidneys and pulmonary vessels, increases the breathing space, and overcomes the tendency to form fat in the thoracic and abdominal cavities." These objects are attained by reducing the fluid intake to 15 or 20 ounces: one cupful of tea, coffee, or cocoa at breakfast and tea time, a wineglassful of wine with as much water at dinner-time, and 4 or 5 ounces of plain water with a tablespoonful of whisky or brandy in the evening. The food should consist of eggs, meat, fish, poultry, tripe, dry toast, rusks, or plain biscuits; at dinner a tablespoonful of mashed potato, and spinach or cauliflower, followed by a light pudding, and cooked or fresh fruit.

Salt-free Diet.—Common salt is essential for metabolism, but the retention of salt in the tissues, owing to renal inadequacy, leads to hydræmic plethora or œdema of the tissues, and materially increases the work of the heart. Mendel says hydræmic plethora does not lead to œdema so long as the heart and kidneys are sound, but a failure in the circulatory system immediately leads to œdema, which is primarily due to hydræmia. The beneficial effect of exclusive milk diet in these cases is well known, but Romberg believes

the effect is entirely due to absence of salt. Mendel supports this view, and considers the same effect may be obtained from salt-free diet. A diet consisting of 2½ pints of milk, 10 ounces of meat (cooked and eaten without salt), and 10 ounces of salt-free bread, and some fresh fruit, would only contain about 3 grammes of sodium chloride. With an ordinary diet a normal person excretes 15 to 20 grammes of sodium chloride daily, but the food contains more than that quantity. The patient should remain in bed while taking this diet. When the œdema is gone, some cauliflower, fresh-water fish, fat bacon or ham, and milk pudding can be added to the diet. The amount of salt will thus be increased to 6 grammes daily. From this time onward the patient should be instructed to take as little salt as possible. Cereals and fruits contain very little; milk puddings, custards, junkets, creams, omelettes made with sugar, and jelly, also contain little; ordinary bread and meat contain much more.

The Adolescent Heart.—A constitutionally weak heart may occur in a person "made of poor goods," and such condition is usually part of general myasthenia. The adolescent heart, however, according to Herz, is due to a disproportion in growth, the heart and vessels being developed more slowly than the skeleton and those organs concerned with the production of internal secretions. These cases usually do well under a dietetic and hygienic regimen designed to supply the materials for growth, and to strengthen the organism in general. In spite of breathlessness and palpitation after exertion, such persons should gradually train themselves by muscular exercises within their power, avoiding strain, until their heart gains strength and they are able to perform feats of endurance.

The Athlete's Heart.—This is a simple hypertrophy due to strain. It requires moderation in training and due attention to the diet.

Senile Heart.—At the opposite extreme of life the heart often becomes enlarged when the muscular power of the body declines. Foster[1] says: "The dynamic coefficient of the skeletal muscles diminishes rapidly after thirty or forty years of life, and a similar want of power comes over the plain muscular fibres. The heart, though it may not diminish, or even increases in size and weight, possesses less and less force, and diminishes in vigour."

The rules of dietary for the arterio-sclerotic should be impressed on the patient. The most important meal should be in the middle of the day, and an interval of five hours should be made between meals. Dry diet is often useful. Alcohol should be dispensed with if possible. All meals should be light, and consist of easily digested foods.

Hypertrophy and Dilatation.—As regards compensatory hypertrophy, nothing more is needed than the remarks on chronic diseases of the heart. In cases of simple uncomplicated hyper-

[1] "Textbook of Physiology," iv. 1549.

trophy, a course of low diet and rest of body are necessary. After this period, the keynote of life should be **moderation.** Small meals are better than large ones; they distend the stomach less, and do not embarrass the heart. The stomach and bowels must be kept in order. There is probably a persistent arterial hypertension, which should be treated as for arterio-sclerosis.

Dilatation shows the existence of weakness or degeneration of the myocardium. In simple dilatation due to anæmia or pyrexia, it will be sufficient to improve the quality of the blood and general nutrition. The treatment for chlorotic anæmia is the proper one. In all other cases we must endeavour to maintain the tissues in the highest state of health possible, to enable Nature to resist the hydrostatic pressure resulting from derangement of the circulation. The diet should be light and nutritious. A small amount of butcher's meat, fowl, fish, light vegetables, and fruit; eggs, custard, jelly, blanc-mange, milk puddings, bread-and-butter. The digestive organs must be carefully watched. All those articles to be avoided in dyspepsia and alimentary catarrh should be forbidden now. If the arterial tension is high, or there is evidence of alimentary toxæmia, a lacto-vegetarian diet would be beneficial. The amount of saccharine and fatty foods should be kept low. Liquids should be limited. A small amount of tea and coffee may be allowed. Persons who have been accustomed to alcohol may have a small amount of good wine or spirit. The quantity should be fixed. Smokers may be allowed one ounce of tobacco a week—a pipeful twice a day.

When the dilated heart fails, rest in bed is a necessity. An attack of bronchitis or gastric catarrh now often prostrates the patient. We may have to contend with nausea and distaste for food. Some patients can swallow nothing that requires mastication. Milk, therefore, must be the basis of the diet. The patient may object to it, but the lime-salts in it are of especial value now. Huchard says the patient will not die because he takes milk, but he will die if he takes ordinary food. Most of the distressing symptoms are due to alimentary toxæmia; therefore milk is the proper diet. Such patients are often difficult to feed. If milk is vomited, mix it with barley-water, soda-water, or lime-water (but not with sodium citrate), to prevent formation of curds. If it is then rejected, avoid gastric feeding for a few days, and resort to rectal feeding. An absolute milk diet should be given for ten or fourteen days. It may be plain, raw, boiled, baked, or as junket. After this time give very small portions of custard, junket, jelly, milk puddings, raw meat, raw ham, oysters, and gradually increase the quantity. Next give a bit of boiled sole or whiting, then breast of chicken or pheasant, tender mutton, under-cut of beef, and so on. As the patient improves, gradually reduce the quantity of fluids to $1\frac{1}{2}$ or 2 pints a day, at the same time increasing the solids. This is exceedingly important when there is œdema or ascites. A little tea would be valuable to the patient, and alcohol may be

necessary. The greatest need for alcohol occurs in those patients who do not improve with drugs. It is an invaluable remedy when it has not previously been abused. The quantity should not exceed 2 ounces daily. This would be contained in 5 ounces of good brandy or whisky, and should be given in dessertspoonful or tablespoonful doses, well diluted. The advantages of alcohol are—It raises the force of the failing heart and steadies its action, it eases pain and dyspnœa, it promotes sleep, it temporarily takes the place of food. The disadvantages are—It irritates the stomach, causes intolerance of food, congests the liver, excites the nervous system, and ultimately damages the myocardium. But it is exceedingly valuable, and nothing else answers quite the same purpose.

Changes in the Cardiac Muscle (*Myasthenia, Myocarditis, and Fatty Degeneration*).—The best-known cause of myasthenia is influenza. But it may be caused by other pyrexial diseases; also gout, rheumatism, syphilis, tuberculosis, and malaria; alimentary toxæmia, hyperthyroidism; alcohol, tobacco, etc., and many non-toxic causes of general debility. The *gouty heart* is cardiac myasthenia in a gouty person. In fatty heart the muscular fibres have undergone a degenerative change. In all these cases, however, the dietetic treatment is similar. The digestion is usually feeble; atony of the stomach is common. The food, therefore, should be light and easily digested, but very nourishing. There should be an interval of five hours between the meals, but a small amount of extract of meat or a glass of wine may be allowed in the middle of the morning, a cup of tea in the afternoon, and a glass of spirit and water at bedtime. The food should be eaten as dry as possible, the principal liquids being taken an hour before meals. Dinner should be eaten in the middle of the day.

Breakfast.—China tea or coffee with cream, no sugar (*saccharin may be used*); dry toast—thin, crisp, and buttered cold; one egg, bacon, or fish; and a little fruit.

Dinner.—Any kind of meat, fish, or fowl, plainly cooked; light vegetables, one potato; custard, junket, jelly, cooked fruit (*sweetened with saccharin*).

Supper.—Similar to dinner.

One of the complications of cardiac failure is torpidity of the liver, hepatic insufficiency, arising from venous engorgement. The liver has more to do than any other organ with carbohydrate metabolism. Therefore lighten the work of the liver by reducing carbohydrates. There is evidence that fats are badly absorbed in severe heart diseases; therefore, reduce the amount of fat. The reduction of fat and carbohydrate necessitates an increased consumption of protein. The patient must be urged to take more meat, one or two eggs, a pint of milk, oysters, and other nitrogenous foods to raise the total value of the food to 1,800 or more calories. Strict moderation in alcohol is necessary; comparatively few cases need it. The general tendency of alcohol is to disturb metabolism and cause

degeneration of the tissues. But it is essential when the patient is confined to bed. Caution, however, should be exercised. The patient is conscious of the relief derived from it, and may ask for it whenever he becomes depressed or feels thoracic oppression. It is easy to pass the limits of usefulness, and to induce the reaction and depression resulting from excess of alcohol. A small amount of any kind of wine which suits the patient may be taken with the food. Perhaps the minimum for usefulness is 2 or 3 ounces of good wine, and the maximum 10 ounces daily. Good Burgundy or Rhine wine would be suitable, but it might, of course, be replaced by an equivalent amount of brandy or whisky.

Tea and coffee should be taken in moderation only. Both contain about 1·5 per cent. of caffein, therefore 1 ounce contains ½ gramme; but an ounce of coffee would only make 1½ pints of "coffee," whereas an ounce of tea would make 4 pints of "tea"; therefore, from this point of view tea is the safer beverage. Moreover, the essential oil of tea dilates superficial bloodvessels and lowers blood-pressure; that of coffee has the opposite effect. Cocoa is better than either of the foregoing in some cases. The theobromin is beneficial, it is diuretic and lowers blood-pressure, and is frequently prescribed as a remedy. It is better to boil "cocoa-nibs" in water or milk than to use powdery preparations. If the cardiac pressure suddenly drops, coffee and its caffein would be more valuable than tea or cocoa.

The Oertel treatment by dry diet is valuable in many cases of myocardial degeneration. The objects are to reduce the volume of blood, increase the proportion of albumin,strengthen the cardiac muscle, equalize the arterial and venous blood, check the cardiac dilatation and degeneration, and remove fat from the heart, the abdominal cavity, and subcutaneous tissues. These objects may be effected by dry diet, combined with graduated exercises at an elevation of 2,000 feet above the sea-level. At this elevation less strain is thrown on the myocardium, and there is a dilatation of the superficial vessels and accumulation of blood in the cutaneous area, to the relief of the pulmonary circulation. Of course, it is useless to recommend residence and exercise at a high altitude to a lady who has never walked in her life, or to a poor clerk or struggling shopkeeper. The lady may, however, benefit from a change of air, and the dry diet. The shopkeeper must be content to take his exercise at a lower elevation. In each case the fat may be reduced by the Banting-Harvey, Oertel, or Ebstein diets, or by a milk diet, the whole food being reduced rather than any special item. At the commencement of treatment great caution should be used as to the exercise. The patient should be ordered to walk up a gentle slope each day, the distance and gradation gradually increased. The Nauheim or Schott method of treatment is of great value in these cases. The treatment consists of exercises and baths which can be used at home. It is most useful when the heart has lost tone or become flabby from sedentary occupation or

want of exercise in the open air, combined with portal congestion and alimentary toxæmia. Graham Steele says: "With a sedentary occupation and abstinence from exercise, combined with a good appetite, it is easy for certain individuals to pass into a condition remote from that known as 'fitness.' No one expects 'good wind' in a stout person; and his 'bad wind' is largely due to the condition of his heart, which has been debilitated. . . . One of the chief signs of the failing heart is the growing failure of 'wind.' Training will improve the voluntary muscles, and so, undoubtedly, will it improve the cardiac and respiratory muscles."

CHAPTER XIX

DISEASES OF THE RESPIRATORY ORGANS

The lungs are the chief centre for gas exchange. The amount of oxygen assimilated and carbon dioxide excreted increases from childhood to adult age, and declines with the activity of the body. The amounts vary with the circumstances and condition. Muscular activity increases metabolism, also the oxygen absorbed and CO_2 excreted. Rest reduces metabolism and diminishes the oxygen and CO_2. The consumption of food increases respiratory activity, especially about an hour after the principal meal. The respiratory quotient is greatest on a carbohydrate diet. Alcohol, tea, and the ethereal oils, diminish the output of CO_2. Fever increases the consumption of oxygen and output of CO_2.

Whatever interferes with respiratory activity is a serious hindrance to metabolism. Diseases of the lungs diminish their capacity for respiratory purposes, and cause a diminution of the gaseous exchange. Therefore a perfect respiratory apparatus is necessary for the well-being of the organism. Interference with the respiratory function may be due to—(1) Changes in the air passages, (2) changes in the respiratory movements, (3) changes in the circulation through the lungs.

Catarrh of the Air-Passages.—Catarrh of the nasal passages, larynx, trachea, or bronchial tubes obviously interferes more or less with respiration. There is no need to go into details here respecting these disorders. The exciting causes are well known. The fever diet, given in a subsequent chapter, is adapted for the treatment or influenza, colds, pharyngitis, laryngitis, and bronchitis, or acute bronchial catarrh.

Chronic catarrh of any portion of the respiratory passages requires ordinary mixed diet of a nourishing character. Children, especially those who are scrofulous or rickety, should have plenty of new milk, scraped raw meat, or underdone tender meat, pounded chicken, fish, cod-liver oil, and salt baths. Adults require light nourishing food in which protein and fat figure well. Salted foods are beneficial in many cases. The ash of mucus contains more sodium chloride than the ash of blood. Mucus becomes less tenacious in a salt solution, and salt taken in water acts as an expectorant. But the saline waters, containing chlorides, are distinctly alterative. Alkaline carbonates are also valuable. Dilute alkaline solutions excite ciliary movements and re-establish the vibrations suppressed

by catarrh. Sulphur waters also have a beneficial alterative effect. Many alkaline, chloride, and sulphur waters, taken internally or used locally in a fine spray or pulverization, hasten the curative effect of other remedies.

Pneumonia, Pleurisy, and Acute Bronchitis.—It was formerly the custom to treat these diseases with a low diet, consisting of beef-tea, mutton broth, water-gruel, rice-water, barley-water, toast-water, tea, jelly, lemon-water, etc.; and when the body became profoundly weak, to prescribe huge doses of alcohol. A low diet is still recommended by some authorities. Thus one writer says for lobar pneumonia: "One and a half pints of milk or whey, 1 pint of soup, and one egg daily will represent a sufficiently full dietary." But if we examine the reports of experiments in metabolism, we shall find this meagre diet is very insufficient. Ewald made observations on five cases of pneumonia, and found the excretion of nitrogen averaged 19·13 grammes per diem, necessitating a supply of 1·5 to 2·0 grammes of protein per kilo of body-weight, or from 112 to 126 grammes of protein daily, to maintain the nitrogen in equilibrium; and the combustion in the tissues was so great as to require from 2,500 to 3,000 calories to maintain the weight of the body. Instead, therefore, of diminishing the amount of nutriment, we ought to endeavour to meet the increased demands by giving such foods as the body can digest and assimilate. It has been shown that proteins and carbohydrates are nearly as well digested in fever as in health; but fat is not quite so well absorbed. We should therefore endeavour to give the typical fever diet (*q.v.*). Milk is the best food. Eggs are also valuable. Carbohydrates are especially valuable—*e.g.*, farinaceous foods, sugar, lactose, glucose, extract of malt, etc. Jelly is useful. A little fruit juice, a few grapes, strawberries, or apple sauce may be given. The rules for the administration of stimulants should be adhered to. When the pyrexial stage is over, the solidity of the food should be gradually increased until the diet for convalescence from fever is attained. But it should never be forgotten that an excess of solid food may cause indigestion, flatulence, discomfort, and perhaps catarrh of the stomach. Therefore the return to ordinary food should be very gradual.

Chronic Bronchitis and Emphysema.—Chronic bronchitis is a frequently relapsing catarrh of the bronchial tubes, occurring chiefly in the spring and fall. It may increase until it becomes a persistent bronchorrhœa. Bronchitis and bronchial catarrh are frequently associated with disturbances of the circulation, especially diseases of the heart. This disease is common in people over fifty years of age. It occurs in the rich who live too well and sit all day, and in the poor who work hard and are not well fed, who are exposed to vicissitudes of the weather, to irritating fumes, noxious gases, and dust, especially industrial dust.

When elderly and working people suffer from chronic bronchitis, they ought to have a light diet of a very nourishing character.

The food should be varied to encourage appetite. Meat and fish are necessary. An excessive amount of sweet foods, such as cakes, puddings, and cooked fruit, would be injurious; but plain milk puddings, bread-and-butter puddings, custards, etc., would be correct. A generous wine, such as Burgundy or port, would be useful, and an occasional dose of whisky is beneficial. If the catarrh is due to cardiac disease, the dietary detailed under that heading should be adopted; if there is gastro-intestinal catarrh or hepatic insufficiency, the dietary for those disorders should be adopted.

When bronchial catarrh afflicts the wealthy, a different method of treatment is often necessary. Such people often eat and drink too much, and take too little exercise. It is generally useless to send them to bed for their catarrh. They often have evidences of hepatic insufficiency, possibly a large liver, and hæmorrhoids. In these cases the intake of food and output of energy must be made to balance. A spare diet, reduction of alcohol, and increase of exercise must be insisted on. Ebstein's or Oertel's diet should be prescribed, spirits should be forbidden, and very little wine allowed. Exercise must be ordered. It must be taken slowly at first, but gradually increased in rapidity and duration. Walking is the best mode of exercise. A course of waters at Harrogate, Pitkeathly, Marienbad, or Carlsbad, would be beneficial.

Bronchial trouble comes to many people with an increase in weight. Obesity causes dyspnœa or breathlessness on exertion. This tends to sitting down, which in turn causes increase of obesity or fatty heart, and chronic bronchitis and emphysema are gradually evolved. In these cases the treatment should really be that of the main cause—obesity. There is no need to repeat the directions given for that complaint. We must bear in mind the associated enfeeblement of digestion. The carbohydrates ought to be reduced to half the usual allowance, and proteins increased somewhat. The Banting, Von Noorden, Ebstein, or Oertel diet may be instituted. The retention of fat in the diet is useful in bronchitis. Cod-liver oil has a long time figured among the remedies for this disease, and we cannot suppose its curative effect is entirely due to the trace of iodine. Ebstein's diet contains more fat than Oertel's, and is preferable. The milk cure may be adopted when abdominal plethora is very marked. The whey-cure and grape-cure have also been found useful in the same kind of cases. When the weight is diminished, there should be a permanent reduction of carbohydrates, especially potatoes and other starchy foods, and many extra or unessential items of food should be forbidden.

Chronic Pleurisy, Hydrothorax, etc.—Ordinary light food of nutritious character, and sufficient in quantity to prevent emaciation and increase strength, is essential. But two special diets are suitable for these conditions. The "dry diet" and the "salt-free diet" detailed in the chapter on special diets and elsewhere have a beneficial effect by promoting the absorption of the fluid.

Asthma.—Asthma is due to a constriction of the bronchial channels. Various theories have been put forward to explain its occurrence. The theory of Reisseison, that it is due to muscular spasm of the bronchi, was long held; but Weber's theory of hyperæmia and tumefaction of the mucous membrane is supported by many authorities. Williams, on the other hand, says the dyspnœa is due simply to an exaggeration of the rhythmical contraction and dilatation of the tubes which occur in normal conditions. The disease is often associated with toxic causes—*e.g.*, alimentary toxæmia, Bright's disease, etc.; or obstruction arising from adenoids, ethmoiditis, or hypertrophic rhinitis. Laryngismus stridulus of children, also called "asthma thymicum," "asthma laryngeum," "spasm of the glottis," etc., is probably a reflex phenomenon. Asthma may also be associated with emphysema, organic disease of the heart or kidneys, uterine derangements, and various obscure causes. Many causes of asthma are curable, and an endeavour should be made to bring this about.

Treatment—(1) *During the Attack.*—The most efficacious dietetic procedure, using that phase in a wide sense, would be the inhalation of compressed air or oxygen. A cylinder might be kept in readiness for the patient's use. Strong coffee is also very efficacious in some cases. It should be made from Mocha berries in the proportion of 2 ounces to ¼ pint of boiling water. Romberg found sucking small pieces of ice afforded relief, and the application of ice in a towel along the course of the pneumogastric nerve in the neck gave relief in five minutes. Alcohol in the form of spirit and water (gin, brandy, or whisky) gives relief in many cases. But the tendency to form a habit renders alcohol a dangerous remedy.

(2) *Between the Attacks.*—Plain mixed food is the best. It should consist of easily digested protein and carbohydrate foods. Many patients have idiosyncrasies to special articles. In such persons an attack may be precipitated by eating eggs, pork, lobster, truffles, and asparagus; therefore these things should be avoided. We cannot tell beforehand what will be the effect of any kind of food. Every addition to the diet must be experimental. Gluttony or carelessness in the diet will bring a speedy punishment. The asthmatic person must sacrifice his desires, inclinations, and tastes. A long list of articles to be forbidden might be made out. They have already been given under indigestion and liver complaint (*q.v.*). A few articles which should be forbidden may be especially mentioned—*e.g.*, pork, veal, hashed meat, entrées, rich sauces, salmon, eel, mackerel, and other heavy fish, lobster, truffles, asparagus, pastry, boiled puddings, suet dumplings, cheese, nuts, dried fruits, pickles, spiced sauces, and an excess of sweet foods. After forbidding these articles, attention should be given to the effects produced by other foods, and a suitable dietary built up by a process of exclusion. In one case it will be found that asthma is induced by an excess of all kinds of carbohydrates, especially sweet foods, causing flatulence, distending the stomach, interfering with respira-

tion, and reflexly causing dyspnœa. In another case, butter and fatty foods disagree. Foods cooked in fat should in all cases be taboo. In a third case, animal foods may be responsible for the attacks. Thus we may be led to prescribe a lacto-vegetarian or sour-milk diet for one, purin-free diet for another, ordinary light nourishing diet for the debilitated, or meat and hot water diet for the gouty. Alimentary toxæmia can be held in check, reflex nervous asthma prevented, and the debilitated person cured. The total amount of food should not be too low. Some asthmatic persons consume too little, to the detriment of their general health. Four light meals, not too bulky, are better than two or three heavy meals. The heaviest meal should be in the middle of the day. The supper should be light, not late, say two or three hours before bedtime. Eating between meals should be forbidden. Thus the stomach will not be overloaded, taxed by indigestible foods, or irritated by condiments, spices, and alcohol; and a feeling of *bien-être* will be encouraged. Animal food may consist of tender lean beef or mutton, chicken, pheasant, guinea-fowl, rabbit, and white fish. Milk sauce, onion sauce, apple sauce, or jelly may be eaten with them. Potatoes may be eaten in moderation, especially baked ones. Cauliflower, spinach, spring cabbage, boiled lettuce, chard, seakale, and tomatoes may be allowed. Heavy vegetables should only be taken as a purée. Milk puddings, custard, junket, and cooked fruits may be eaten in moderation. Very little fluid should be taken with the food. It may consist of tea or coffee for breakfast; plain water, a glass of hock, claret, dry champagne, or even a small amount of spirit and water for dinner. Sweet wines, strong wines, beer, ale, and porter should be forbidden. The chief drink should consist of ½ pint of hot water with a little common salt and bicarbonate of soda half an hour before the meals.

The patient must avoid excitement and ought to live in a pure atmosphere. The sea-coast or mountain air is preferable, and the country is better than the town. Many people have been cured of asthma by removing from a dusty or smoky manufacturing district, and others relieved by going from a low-lying country district to live in London or some other city.

Hay Asthma or Hay Fever requires dieting in a similar manner to spasmodic asthma.

CHAPTER XX

TUBERCULOSIS

This chapter will deal with the dietetics of tuberculosis in general, as well as acute and chronic phthisis (pulmonary tuberculosis).

The predisposition to tubercle is strongest in persons of feeble and delicate constitution. But people who usually possess good health are not permanently immune to this infection. A simple catarrh, catarrhal pneumonia, or whooping-cough, may prepare a nidus for the reception and propagation of tubercle bacilli. A feeble, ill-nourished body is in greater danger of tuberculosis than a healthy, vigorous, and well-nourished body, because the nutrition is easily disturbed, and the cells proliferate rapidly with the production of feeble descendants. The lymphatic glands, especially in children, participate in this irritability and morbid tendency to proliferation of the cells. They readily enlarge, and suppuration is easily provoked. Such persons are said to be scrofulous, and are very prone to infection by tuberculosis. Moreover, this delicacy of the cellular elements is transmissible from parent to child, wherefore it is said consumption is hereditary. It is better to say, "There is an hereditary susceptibility to consumption." The child of tuberculous parents may be born with evidences of the disease, in which case it is *congenital*, although W. B. Ransom believed this to be rare, and said if the disease is developed later in life, it is probably *acquired.* Lazarus-Barlow[1] says: "It is certain the semen of tubercular persons may contain tubercle bacilli; but the direct infection of the ovule is doubtful." Kanthack[2] also doubts this mode of causing congenital tuberculosis, and considers the mother is first infected. Nevertheless, the wives of tuberculous men frequently escape the disease while their children inherit it, or a special susceptibility to it. Placental tuberculosis is not rare, and therefore a tuberculous mother may directly infect her child.[3] Tubercle bacilli introduced into the organism during fœtal life may remain latent and develop in later life. "Latency" has been observed in syphilis and leprosy in human beings; it has been observed in the lower animals—*e.g.*, pebrine in silkworms; and also in vegetables—*e.g.*, potato disease.

The inheritance of susceptibility was long held the chief cause of

[1] "Textbook of Pathology," p. 360.
[2] Allbutt's "System of Medicine."
[3] Engel, *Wien. Med. Klin.*, Heft ii., 1909.

tuberculosis in the children of tubercular parents. Ransom considered "a special susceptibility is not necessary, and its existence is not proven." But we cannot deny the transmission of acquired characteristics. Evolution is a proof of its occurrence. Lazarus-Barlow says: "If the inheritance of parental characteristics is borne in mind, the possibility of such an explanation cannot be denied."

Tubercle in the parents is not the only cause of susceptibility to the disease in the offspring. The child's tissues may be rendered susceptible by improper diet, hunger and want during the period of growth, absence of fresh air, living in badly ventilated and overheated rooms, or frequent exposure to wet and cold. Adults are rendered susceptible by the same causes. A person born with a sound constitution rarely becomes infected while the body remains well nourished and the cells retain their normal characteristics. But when the tissues get into such a condition that wounds do not readily heal, the organism has undergone a change; the cells have lost their vigour and cannot resist infection; the phagocytes are no longer able to overcome the invading bacilli; the immunity is broken down; the antibodies—alexins, opsonins, agglutinins, amboceptors, or whatever name we give them—are deficient, and tubercle bacilli work their way into the blood and tissues, and cause the morbid changes characteristic of tuberculosis. This condition is favoured by alcoholism, insufficient food, prolonged discharges, suckling, sexual excesses, syphilis, chlorosis, ulcer of the stomach, various disturbances of metabolism, immoderate study, and depressing mental conditions.

The infection may be acquired through the air or food. Exposure to an atmosphere charged with tubercle bacilli renders the risk of infection great. Household dust consists largely of organic matter, and is one of the chief sources of tuberculous infection, especially when tuberculous persons are careless in regard to their sputum. Industrial dust is another source of infection. An analysis of 2,161 cases of tubercle showed that 1,095 cases were associated with the inhalation of dust during occupation. The chief sources of food infection are meat and milk. The flesh of tuberculous animals is not necessarily infectious—in fact, muscular tissue rarely contains deposits of tubercle. But tubercle bacilli abound in the lymphatic glands, and it is the presence of these little organs which makes the consumption of tuberculous meat dangerous. Besides muscular tissue, the lungs, udder, mesentery, and other organs are consumed by the poor. These are often infected, and are a source of danger. Experiments by Sims Woodhead showed that tubercle bacilli in these tissues are destroyed when they are cooked at a proper temperature; but he made rolls of meat, such as are sold by the butcher, and placed infected tissues in them, and found that a joint weighing 6 or 7 pounds did not attain a higher temperature than 140° F., and was not sterilized throughout; and a roll of 3 or 4 pounds of meat might not become sterile in ordinary

cooking. With these exceptions, the ordinary methods of cooking are more or less a safeguard against infection.

Tuberculosis may be transmitted from cattle to human beings by means of milk. It is probable that a large proportion of tubercle of the glands, bones, brain, and serous membranes is derived from this source. Von Behring said the chief cause of tuberculosis in man is the contraction of bovine tuberculosis in infancy, through being fed on milk, and such tuberculosis is often latent and develops in adult life. Koch denied this strenuously; but the British Royal Commission afterwards decided that milk is a source of tubercle to mankind, and is one of the causes of the high mortality from this disease in children. Nevertheless, seeing the importance of this fluid for feeding infants, children, and invalids, we ought not to forbid its use, but should endeavour to secure a pure milk-supply.

Prophylaxis.—The marriage of healthy persons, nearly of an age and not related to each other by blood, is essential to avoid the risks of tuberculosis in the offspring. Children born of tuberculous or scrofulous parents should be subjected to a régime which will tend to eradicate the susceptibility or render the soil unfit for the propagation of tubercle. The milk of a healthy woman is the best food for an infant; but tuberculous mothers ought not to suckle their young. A wet-nurse, providing she is free from taint of tubercle or syphilis, is the best substitute for the mother. When woman's milk is not obtainable, the child must be fed in the manner indicated in the chapter on Infant Feeding. Milk of the cow, goat, ewe, or ass should form a principal part of the diet after the period of dentition until the child can take an adequate portion of minced meat, fowl, or fish. The diet in childhood should be generous, and contain a large proportion of proteins. It was formerly thought bread and potatoes favoured the development of tubercle; and so they may do, when the protein is deficient, but they are very valuable sources of mineral salts. Oatmeal is a stimulant of metabolic activity and growth, and, when combined with milk, is an admirable food. Fat should figure well in the diet to meet the demands of the organism for energy, and, as Sawyer says, "to feed the cells which eat bacilli." Cod-liver oil is largely prescribed for delicate children, but every child is not benefited by it. It is usual to divide children having a predisposition to tuberculosis into two groups: (1) *The scrofulous type*—fair, coarse-skinned, muddy-looking, rather fat, clumsy, and slow both mentally and bodily. These are not benefited by cod-liver oil, even when they exhibit enlarged glands. It upsets their stomach, deprives them of appetite, and hinders nutrition. They frequently show a distaste for fatty foods, which is considered a harbinger of tuberculosis. (2) *The tubercular type*—dark-haired, beautiful children, thin, slender, having a clear skin through which the veins are visible, excitable, mentally quick, and of great bodily activity. These children, as a rule, derive much good from cod-liver oil. If they

have a distaste for it at first, it is soon overcome, and they speedily become accustomed to it. They should have it for months together, leaving it off for a few weeks, and then again taking it. The initial dose should be small and gradually increased until they can take three or four teaspoonfuls daily. Emulsions of cod-liver oil and malt may be used.

Baths are beneficial to such children, and it so happens that those who cannot take cod-liver oil are most benefited by them. Sea-water, sea-salt and water, brine baths, bromo-iodine and sulphurous waters, are better than plain water. They are justly esteemed alteratives and promoters of metabolism. Fresh air and exercise are equally important.

In adults the defensive powers of the organism may be increased by similar measures to the foregoing. High feeding is one of the best means of promoting metabolism, encouraging the formation of healthy tissues, and forming the antibodies essential to protect the organism. The feeding of a person believed to have a predisposition to tuberculosis or suffering from pre-phthisis, should be carried out in exactly the same manner as a person in whom the disease actually exists. Meat, fowl, milk, and various forms of fat should be generously prescribed. Want of appetite, nausea, vomiting, distaste for fatty foods are evidences of that catarrh of the stomach which is common in pre-phthisis. Due attention must be paid to this condition. The stomach must be coaxed and even indulged to a certain extent. Medicines must be given to aid its recovery, to promote appetite, and encourage the alimentary secretions. If milk disagrees, those means must be adopted to modify the fluid which have been so often detailed. The milk of animals fed on mountain pastures is richer in protein and fat than other milk. Therefore *the milk cure* in a district where goats, ewes, and asses are the common source of milk is commendable. The ancient custom of taking new milk, *fresh and warm from the cow*, has the support of science. Such milk, when the animal is healthy, is the richest in vitamines, enzymes, alexins, and other antibodies. Therefore it may suffice to send the patient to a farm-house where the milk may be obtained.

The importance of living in a pure atmosphere and of freedom from danger of infection by tuberculosis cannot be too strongly urged. A person having a known susceptibility to the disease should not live in the same house as a tuberculous person, and most certainly should not occupy the same bedroom. Tuberculous persons must use a proper spit-bottle, which should be disinfected daily. Removal from town to country, a long sea voyage, a residence in a warm, dry climate, are proper recommendations. If a person must work, he may find suitable employment in the highlands of Canada, in California, Colorado, South Africa, New Zealand, or other places reputed to be curative. By such means the predisposed person may so improve his health that the threatened invasion will not occur, or that the invader will be overcome.

Treatment of the Tuberculous Child.—Phthisis is not prevalent among young children, but modern methods of diagnosis show that a large proportion of children are tainted. Hamburger of Vienna applied Von Pirquet's cutaneous test to 509 children. Not one child under a year old gave evidence of the disease; but from one to eleven years of age there was a steady increase in the reactions, and 90 per cent. of eleven year old children reacted. Hamburger says: "Tuberculosis is a true children's disease. Almost everyone acquires it some time, and mostly during their earlier years." Kelynack who found 8 per cent. of children tuberculous at one year old, says: "The tissue soils of infancy and childhood afford good ground for the seeds of tuberculosis, which exacts a heavy toll on life's earlier years." Engel says Von Pirquet's test shows tuberculosis is comparatively rare in infants at the breast, but increases in frequency with age, until at puberty about half the children are affected." In infancy the disease is a generalized tuberculosis. From infancy to puberty the glands are almost always first affected, the bronchial glands included. At puberty the glands cease to be seriously affected, and pulmonary phthisis becomes more common. Tuberculosis in adults is often due to a recrudescence of tuberculous lesions which have slumbered since childhood.

Tuberculous children should live mostly in the open air. Sunshine is of importance to them. The sanitary arrangements of the house should be perfect. Warm clothing, regular exercise, and baths are essential (*vide* Prophylaxis). They should be protected from measles, whooping-cough, mumps, and all diseases which depress the vital powers.

The food should be good and abundant. Protein and fat should figure largely in the diet. Protein should be in the proportion of 2·5 to 3 grammes per kilo, or 1½ grammes per pound of body-weight. It should be derived mainly from animal foods. The requirements of children given in the chapter on Feeding of Children, should form the standards. The animal foods should consist of milk, eggs, egg-flip, custard, junket, milk-jelly, milk puddings, minced raw meat, meat-juice, ordinary cooked meat (scraped or minced for young children), chicken cream or panada, pounded fish with cream or butter. Plenty of fat should be given in form of butter, cream, cod-liver oil, olive-oil, peanut-oil (*arachis*), suet, and boiled fat bacon. Bone-marrow is especially good. It should be eaten raw, spread on bread, seasoned with salt, or put into soup or porridge. When milk is not taken readily, it can be partly replaced by raw eggs and cream; by dried milk (*e.g.*, Truemilk, Cow and Gate brand, etc.); by casein preparations (Protene, Sanatogen, Plasmon); or meat powder ("meatox"). Carbohydrates should consist of milk puddings, standard bread (*wholemeal*), and oatmeal porridge. It has been shown that certain bodies called "vitamines," in *unbolted* flour and oatmeal, are important provocatives of growth and metabolism; therefore these materials should be

prescribed in preference to fine flour, white bread, or fine oatmeal. Sugar, jam, marmalade, treacle, and honey are excellent carbohydrate foods, and ought to be allowed without stint as a means of encouraging the consumption of bread or porridge. Starchy foods—*e.g.*, sago, tapioca, arrowroot, and cornflour—are not as a rule so good for tuberculous children. Instead of puddings made of them, children ought to have plum-duff, suet dumplings, and roly-poly jam puddings, in all of which suet is incorporated. Care must be taken that the suet is shredded very fine. As a general rule, when a child rebels against suet puddings, cold boiled bacon, and other fatty foods, it will be found that he is suffering from gastric catarrh. When this is the case, the lighter milk puddings—*e.g.*, rice, sago, and tapioca—must be given while the stomach recovers. At the same time the parents should be warned that an excess of sugar, jam, etc., may cause such catarrh, and these should also be temporarily forbidden.

The feeding of delicate children is an awkward problem for the families of the poor. There are many children in England who get very little meat, and who never taste milk except during illness. In such cases we must recommend skim milk, if other cannot be got; and soup made of pea-flour or lentils and flavouring herbs. These are good sources of protein. Foreign meat is much cheaper than English meat, and should be used when the home product cannot be obtained. In Scotland the national diet is oatmeal and milk. For centuries the stalwart men of the North were fed on this diet. There is evidence that the custom is dying out, and this would be a calamity to the peasantry. The poor of Ireland are badly fed. J. D. Wynne, writing about tuberculosis, says: "The food of great numbers of the poor people in Ireland is deficient in nourishing properties. The potatoes and tea of the Irish peasantry form a diet very inferior to the oatmeal and milk so largely consumed in Scotland." Hussey, in his "Reminiscences of Ireland" (1904), says: "Defective dietary has been reducing our national stamina for forty years. Previous to that time our peasantry were robust and little troubled with consumption. They lived on bread made from home-grown wheat, milk, potatoes, and stir-about. Now they live for the most part on tea and bread made from imported flour, and milk is not obtainable." The physician, therefore, must think over the dietary of his peasant patients, and carefully consider the cheap sources of protein and fat, for these are the most expensive articles (see p. 538).

Treatment of the Tuberculous Adult.—When tuberculin tests are used, a large amount of "unrevealed" tuberculosis comes to light. These cases are more numerous than those "revealed" by physical signs. Many cases called *prephthisis*, or merely having a predisposition to the disease, would be pronounced tuberculous after a tuberculin test. The seat of election in adults is the pulmonary apex. Here the first symptoms of tubercle usually present themselves. There may, of course, be tubercle in the bones,

glands, and other organs. But so far as treatment by diet is concerned, it matters not what part is primarily affected. The food required is practically the same. Many persons recover from the disease. Small masses become transformed into fibroid tissue; larger masses calcify; cavities contract and cicatrize. Some patients remain well only a short time, others for many years, and some are permanently cured. To encourage the healing process by raising the standard of health and prevent fresh infection or auto-infection is the object of all treatment. With treatment by drugs, tuberculin, or vaccine, etc., we have nothing to do in this book.

The diet of a tuberculous person should be carefully planned. The food should be generous. But the patient will derive no advantage from a great accumulation of fat in the tissues. An increase of adipose tissue does not add strength to the body. It may increase dyspnœa and prevent much needed exercise. A great change has come over medical opinion in regard to the diet. Writing in 1835, Clark said: "Overfeeding is a prevailing error. A delicate, puny girl of seven, with strumous constitution, is given the same dinner as a robust youth of seventeen, and both are given as much meat as is adapted only to persons of adult age and matured strength. During the early stages of phthisis the diet ought to be mild and even antiphlogistic; as the disease advances the diet must be regulated with the circumstances. It is erroneous to suppose emaciation can be checked by an additional quantity or increased quality of food. . . . In many cases a change from mild to stimulating diet would interfere with the curative process." Stokes said the diet ought to be of the least stimulating kind—milk, farinaceous foods, and light vegetables; but milk is of more value than the whole *materia medica*. Graves (1840 to 1850) rebelled against this regimen, and said: "Make your patients lay aside slops and tea; let him take fresh meat three times a day, wholesome bread, and good beer." Trousseau gave the same advice, but Clarke strenuously opposed it. Watson at a later date considered a low diet should be prescribed when there are signs of inflammation, a full and generous diet when the disease is spreading. "The commonest error," he said, "is that of reducing strength by needless restriction of nutriment." At the present day, full and generous feeding is the rule. The diet should contain a large proportion of protein, 2 to 3 grammes per kilo, and total energy of 50 or 60 calories per kilo. But even at the present time there is great variation in the diet. Irving Fischer[1] found in ninety-six sanatoria that the protein prescribed varied from 160 to 300 grammes, and the total energy of food from 2,500 to 5,000 calories daily. There has of recent years been a reaction against forced feeding, and the higher quantities are not generally prescribed.

Experiments have shown that proteins have greater effect in arresting tuberculosis than carbohydrates or fat. They are more

[1] Transactions of the National Association for the Study and Prevention of Tuberculosis, 1906.

stimulating, provoke metabolism in the cells, and a more rapid change of the body. It used to be said that no particle of the human body remains the same for more than seven years. This is only true in the aggregate. We know, however, that effete cells are destroyed and new ones are formed. If the diet induces more rapid changes, it may chance that the new cells will have more tone, strength, or vitality, and greater power to resist the tubercle bacilli and toxins. It is believed that these changes are provoked by proteins, and therefore proteins should form a large proportion of the food. A man of average weight should have 150 to 180 grammes daily.

Animal foods are more stimulating than vegetable foods. All kinds of meat may be taken—beef, mutton, lamb, poultry, game, fish, oysters, eggs, and milk. Meat is better underdone and even raw. More meat can be consumed when it is minced or scraped, than when slices are cut from a joint. Raw meat may be eaten without being scraped if it is preferred so, small pieces being dipped in tomato sauce, chutney, or solution of extract of meat. Sweetbread, kidneys, liver, oysters, and snails are particularly good for tuberculous people. Eggs can be eaten raw, or prepared in any way known to the cook—poached, boiled, fried, buttered, scrambled, omelette, custards, puddings, cakes, and soups. Milk is a valuable source of protein: 2 to 4 pints should be taken daily—*e.g.*, ½ pint drunk warm on waking assists the expectoration of phlegm; ½ pint with one or two raw eggs in it should be taken at 11 a.m. and 4 p.m.; and another ½ pint at bedtime. The remainder can be taken in many kinds of food. When unable to take enough meat, the milk should be fortified by the addition of dried milk (Truemilk, Cow and Gate brands) or casein (Plasmon, Protene, etc.). Meat powders—(*e.g.*, meatox) may be taken in soup. Pemmican and other concentrated preparations of meat can be used. Other sources of protein are cheese, lentils, peas, beans, and nuts.

Fat is an important element in the diet. But many people cannot take fat meat, bacon, ham, or butter. The gastric catarrh which is responsible for this inability ought to be treated. Moreover, the cook may be able to devise many articles containing butter and fat. Butter can be used to a great extent in cooking, but it must be free from rancidity and excess of volatile acids. If economical reasons prevent its use, it may be replaced by vegetable butter, such as peanolia, palmine, vegaline, albine, etc. When the patient can take plenty of fat, it may be eaten as butter, cream, cream cheese, fat meat, lard, fat bacon, shredded suet in puddings or boiled milk, fish roe, caviar, cod-liver oil, salad-oil. Many patients can eat quite a lot of boiled fat bacon when it is taken as a sandwich. Pancreatic emulsions of oil can be given to aid digestion. Petroleum-oil is not a food, and should never be given as such.

Two facts require pointing out: When the patient cannot take fat, the proteins can be increased; 100 grammes of protein will yield

40 grammes of fat. Proteins alone will never fatten a patient; 6½ pounds of lean meat or 5½ pounds of lean and fat meat would be required to supply the daily requirement of carbon for an ordinary person; therefore some other source of carbon must be found.

Carbohydrates are an important source of carbon. The most concentrated are sugars (saccharose—loaf-sugar—glucose, lactose, and maltose), treacle, honey, dextrin, and pure starch. Some are less sweet than others, and may be preferred by the patient. Most carbohydrates are easily digested, quickly absorbed, and as a rule give very little trouble to the alimentary organs. But an excessive consumption of sugar may increase an existing catarrh of the stomach, or cause alimentary glycosuria. Massolongo and Danio[1] prescribed from 100 to 500 grammes of sugar daily in foods, such as milk, tea, coffee, or a bitter medicine. They observed no dyspepsia or glycosuria, but always a steady increase of weight.

But pure sugar or starch is insufficient. The body must have mineral salts, especially iron, lime, soda, magnesia, and the phosphates. Therefore the patient should have bread, flour, oatmeal, rice, sago, tapioca, fresh vegetables, and fruit. Wholemeal bread is better than white, because it contains a larger proportion of phosphates, amino-acids, and vitamines. Ordinary brown bread should be avoided, because the particles of bran are too irritating to the gastric and intestinal mucosa. Finely ground entire wheatmeal is better, especially when enriched by germ or maltculm (germ-bread and malted bread). The addition of lentil flour, pea or bean flour to the bread would increase the protein, phosphates, and iron, and give an attractive bloom or golden tint to the loaf. Oatmeal occupies a unique position, its influence on metabolism being shown by its "heating properties." Milk puddings containing eggs are valuable. Creams, such as Bavarian cream, chocolate-cream, rice soufflé, brown-bread cream, and blanc-mange, are valuable sources of nutriment. Soups containing eggs and cream are equally useful. Jellies made from gelatin alone have about the same value as one made from starch and water. A good cook is a valuable assistant to the physician in all these cases.

Superalimentation, or Forced Feeding.—When it is desired to fatten animals quickly, they are kept in a confined space, and, after eating an ordinary meal, are fed by a forcing machine. A similar mode of feeding phthisical patients was adopted by Débove. He discovered by accident, when treating the vomiting of phthisical patients by gastric lavage, not only that it arrested vomiting, but that food introduced through an œsophageal tube was retained and digested when food consumed in the ordinary way was vomited. Extending his observations, he found, when phthisical patients lost their appetite or acquired a repugnance to food, he could introduce

[1] *Rif. Med.*, December 21, 1904.

through the œsophageal tube an excess of food, and it was retained and digested. On this he founded his system of superalimentation. Under the influence of an excess of food his patients gained weight and strength, night sweats disappeared, cough diminished, expectoration almost ceased, there was a general improvement, and frequently perfect healing of cavities. The use of a stomach-tube is unnecessary when patients can consume what we desire them to take; but when they cannot take it, forced feeding may be adopted. When the stomach-tube is not used, resort may be had to concentration of the food. Débove and Dujardin-Beaumetz prescribed from 3½ to 12 ounces of meat powder daily in soup, milk, or cocoa. Dujardin-Beaumetz recommended two tablespoonfuls of meat powder, three dessertspoonfuls of rum-punch, and enough hot milk to make a creamy fluid.

Absorption and Metabolism in Tuberculosis.—The digestion is usually good when the alimentary canal is free from catarrh, and absorption is practically normal in all cases, 97 per cent. of protein and 98 per cent. of fat being absorbed. The metabolic processes are somewhat feeble; the nitrogenous products in the urine are not oxidized so well as in health. Levin found the metabolism of nitrogen as low as 73·46 per cent., and that of phosphorus only 34·68 per cent. of normal.

Reaction against Superalimentation.—The enormous diets prescribed by many physicians have been followed by unpleasant consequences to the patient. Harm sometimes results from the consumption of an excessive quantity of animal food, prolonged high feeding, and idleness. The alimentary organs, in course of time, rebel against excessive work. The liver, the most forbearing organ in the body, suffers from insufficiency and hyperæmia. The blood-pressure becomes abnormally high, and the persistent arterial hypertension produces the same effects as in another person. Lesser evils are failure of appetite, loathing of food, bilious vomiting, and diarrhœa. Bardswell says: "The gradual impairment of the alimentary system is associated with dyspnœa out of all proportion to the lung disease. . . . The point to realize is that great overfeeding is an unnecessary hardship for the patient to undergo, and may do positive harm." Overfeeding is decidedly better than underfeeding (especially the so-called "antiphlogistic treatment" of the early Victorian period), and often results in a permanent cure.

Principles governing the Dietary.—It is impossible to frame a diet applicable to all cases; indeed, every case should be carefully considered, and definite principles acted on. Voit's standard diet, containing 1·7 grammes of protein per kilo and 40 calories of energy, is sufficient to maintain the nitrogen and body-weight in equilibrium during the ordinary occupations of mankind. Therefore, 100 grammes of protein and 2,664 calories are enough for a man weighing 145 pounds (66 kilos). But tuberculosis is attended by a rapid loss of flesh owing to the febrile condition and the breaking down of cells

damaged by the toxins. Therefore the increased oxidation must be met by the consumption and assimilation of more than the customary amount of food. Many physicians generously increase all the constituents of the diet. Bardswell and Chapman, who have made an extended study of the disease, found that the morbid process clears up better and the general health improves more rapidly when more protein is consumed. They used diets containing 2 to 3 grammes of protein per kilo, or 150 to 250 grammes a day. Excellent results followed the use of 150 grammes of protein, and no better clinical or metabolic results were obtained when a larger amount was used; on the contrary, an excess of protein did harm.

It might be thought that equally good results would be obtained from increasing the protein-sparers, but this is not the case. It is difficult to fix the amount of carbohydrate and fat; a good deal depends on the exercise. An average tuberculous patient does well when the total energy is increased to 50 or 60 calories per kilo; and the best diet is that which will cause an increase of 1½ to 2 pounds of weight per week. When the patient has attained a few pounds, say 15 per cent., over his normal weight, the diet should be reduced until it is about sufficient to maintain that weight. The bulk of the food has to be considered. Meat, and especially fat, is less bulky than carbohydrates, and incommodes the patient less than a dynamic equivalent of bread, oatmeal, or other vegetable foods. Cod-liver oil is an easily digested fat, the unsaturated fatty acids aiding the digestion of the oil and other fats. The tubercle bacillus belongs to the acid-fast group, and owes this property to a waxy envelope. It is believed by Williams and Forsyth that this envelope is dissolved by the fatty acids of cod-liver oil, and the bacillus is thereby made a ready prey to the ordinary antibacillary forces of the body.

Alcohol in Tuberculosis.—It was formerly the custom to recommend large doses of alcohol, ½ pint of whisky or brandy a day, on the supposition that it moderated fever, supported strength, diminished the waste of the tissues, and promoted absorption of fat. It is not now prescribed in large doses, nor to all patients. Alcohol is a stimulant, promotes the absorption of fat, and affords heat and energy by replacing fat and carbohydrate. But it does not spare the tissues or prevent wasting of the muscles. In so far as it encourages appetite and encourages eating, it is beneficial. On the other hand, there is evidence that large consumers of alcohol are particularly liable to tuberculosis, and bearing this in mind the battle against tuberculosis should be combined with the struggle against inebriety.

Milk has ever been found beneficial for tuberculosis, and should be freely prescribed. The milk-cure may be adopted. The bactericidal properties of this fluid are greatest when it is first taken from the cow or other animal. Ancient writers urged that it should be drunk in the byres or hovels, as they believed the surroundings of

healthy animals are curative. Other writers recommend that the milk should be drunk out of a vessel made of the root of *Bryonia alba*. Kephir and koumiss are useful; many patients can take them better than ordinary milk.

The raw-meat and meat-juice cure (*zomotherapy*) may be usefully employed (p. 213). According to Héricourt, "it is no exaggeration to say the raw-meat and meat-juice treatment of phthisis yields results not approached by any other means at present available. . . . The enzymes and ferments in muscle plasma may account for its quasi-specific action in tuberculosis."

Meat diet, consisting wholly of meat, fowl, eggs, oysters, sweetbread, kidneys, milt, liver, etc., has been recommended on the assumption that there is an antagonism between the gouty condition and tuberculosis. The idea is to encourage the gouty condition by giving foods rich in purins, and this has been extended by the prescription of urea as a drug. We have elsewhere shown that it is impossible to maintain the weight of the body on animal food alone, as 6¼ pounds of lean meat and 5½ pounds of lean and fat would be required for this purpose. Therefore, this diet is incorrect for tuberculosis. It is far better to give an abundant mixed diet, in which animal food is well represented.

Typical Dietaries for the Tuberculous.—*Brompton Hospital* has from the earliest times prescribed generous meals. The diets are as follows:

Full Diet A.—The standard for men at rest is 3,000 calories, for women 2,500; for men at work or taking exercise 3,500 to 4,000, and for women 2,500 to 3,500 calories.

Breakfast.—Bread, butter, bacon (man 3 ounces, woman 2 ounces), tea, coffee, or cocoa. Bacon is alternated with ½ pound of haddock, ¼ pound of kipper, or porridge consisting of 2 ounces of oatmeal and ½ pint of milk.

Lunch, 11 *o'clock.*—Half pint of milk.

Dinner, 12.30 *noon.*—Meat, vegetables, and pudding. Meat is weighed before it is cooked; the allowance is 11 ounces for a man and 7 ounces for a woman; it consists of hot or cold beef, mutton, or pork with sage and onions. Potatoes are given every day, and one of the following vegetables: cabbage, carrots, turnips; beetroot with hot roast beef, salad with cold beef. Pea-soup is given once or twice a week in place of the former. The allowance per patient is ¼ pound of meat, 1½ ounces of peas, 3 ounces of carrots, 3 ounces of turnips, and ½ ounce of onion. Irish stew is given once a week, the allowance per patient consisting of ¾ pound of meat with bones, 5½ ounces of potatoes, and 5½ ounces of vegetables (carrots, etc.). One of the following puddings is given every day: Plum-pudding, jam roly-poly, suet pudding, and treacle; rice, sago, and tapioca, semolina pudding; boiled rice or cornflour mould and stewed fruit.

Tea.—Bread with ½ ounce butter or dripping and 2 ounces of jam.

Supper.—Half-pint of milk.

Full Diet B.—In addition to the foregoing, the patient is given an extra rasher of bacon for breakfast, an egg for tea, ½ ounce of butter, and 1 pint of milk.

Light Diets A. and B.—These are the same as the full diets, only the meat is replaced by 8 ounces of chicken, rabbit, tripe, or fish (sole, plaice, whiting, or haddock).

Half Diet (for children under twelve years).—Only half the amount of meat, fish, or fowl is given.

At Brompton Sanatorium similar dietaries are in use, and their value is estimated by Shrubsall to be as follows:

	Men.		Women.	
	Grammes.	Calories.	Grammes.	Calories.
Full Diet A:				
Meat—*e.g.*, beef, 11 and 7 ounces ..	312	402·5	198	257·5
Bread, 10 ounces	283	656·7	283	656·7
Butter, $1\frac{1}{2}$ ounces	42	335·1	42	335·1
Potatoes, $5\frac{1}{2}$ ounces	156	124·0	156	124·0
Vegetables, 5 ounces	142	40·0	142	40·0
Rice, $\frac{1}{2}$ ounce	14	49·0	14	49·0
Bacon, 3 and 2 ounces	85	640·0	57	426·7
Sugar, 2 ounces	57	233·0	57	233·0
Milk, 30 ounces	852 c.c.	507·0	852 c.c.	507·0
		2989·3		2629·0
Full Diet B (in addition):				
Bacon, 3 and 2 ounces	85	640·0	57	426·7
Milk, 20 ounces	568 c.c.	338·0	568 c.c.	338·0
Butter, $\frac{1}{2}$ ounce	14	111·7	14	111·7
One Egg	57	70·0	57	70·0
Total		4169·0		3567·4

The dietaries at Mundesley Sanatorium are as follows:

	Breakfast.	Lunch.	Dinner.	Total.	
(a) Smallest Diet:	Grammes.	Grammes.	Grammes.	Grammes.	Ounces.
Bread	70	40	40	150	($5\frac{1}{3}$)
Butter	25	15	10	50	($1\frac{3}{4}$)
Meat	80	30	60	170	(6)
Fish	—	50	—	50	($1\frac{3}{4}$)
Pudding	—	100	125	225	($7\frac{3}{4}$)
Potatoes	—	80	80	160	(6)
Greens	—	40	40	80	(3)
Milk	500 c.c.	—	500 c.c.	1,000 c.c.	(35) c.c.
(b) Largest Diet:					
Bread	90	60	60	210	($7\frac{1}{4}$)
Butter	40	15	15	70	($2\frac{1}{2}$)
Meat	120	80	80	280	(10)
Fish	—	70	70	140	(5)
Pudding	—	150	150	300	(10)
Potatoes	—	90	90	180	(6)
Greens	—	50	50	100	($3\frac{1}{2}$)
Milk	500 c.c.	500 c.c.	500 c.c.	1,500 c.c.	(52) c.c.

The smallest diet contains about 129 grammes of protein and 2,650 calories, and the largest 212 grammes of protein and 4,016 calories per diem.

THE AMOUNT OF FOOD WHICH FIVEPENCE WILL PURCHASE.

	Cost per lb.	Weight.	Containing— Protein.	Fat.	Carbohydrate.	Energy.
	d.	lbs.	lbs.	lbs.	lbs.	Calories.
Beef, sirloin, imported ..	5	1·00	·16	·18	—	1,040
,, ,, ,, ..	7½	·66	·11	·12	—	685
,, round ,, ..	4	1·25	·24	·16	—	1,120
,, ,, ,, ..	6	·83	·16	·11	—	745
Codfish, fresh	3	1·67	·14	—	—	275
,, dried, salted ..	3	1·67	·27	—	—	525
Eggs, 7½d. per dozen ..	4½	1·14	·15	·11	—	725
,, 1s. 0½d. ,, ..	7¾	·68	·09	·06	—	430
,, 1s. 6d. ,, ..	10½	·49	·06	·05	—	310
Milk, 3d. per quart.. ..	1½	3·33	·11	·13	·17	1,080
,, 4d. ,, ..	2	2·50	·08	·10	·13	815
Cheese	6	·83	·22	·28	·02	1,620
,, ...	8	·63	·16	·21	·02	1,230
Peas, dried	2	2·50	·62	·03	1·55	4,140
Cow-peas	1	5·00	1·07	·07	3·04	7,950
Lima beans	2	2·50	·45	·04	1·65	4,065
Haricot beans (white) ..	2½	2·00	·45	·04	1·19	3,210
Lentils	2½	2·00	·52	·02	1·18	3,240
,, ...	3	1·67	·43	·02	·99	2,705
Peanuts	4	1·25	·47	·41	·32	3,200
Bread, 1½d. per loaf ..	¾	6·66	·62	·08	3·54	8,090
,, 2d. ,, ..	1	5·00	·48	·08	2·64	6,080
Sugar, granulated	2	2·50	—	—	—	4,240

Cheap Diets for Poor Persons.—The cost of animal food is often too high for working-class people, especially English foods. It should be pointed out that imported foods have the same protein value as home-grown produce. Foreign meat, fish, fowl, hare, rabbit, butter, and eggs, should always be used when an adequate amount of home-grown foods cannot be obtained; and when the best cuts cannot be obtained, cheaper material must be used. A pound of Australian beef can be purchased for threepence halfpenny, and, with bread and vegetables, would provide a dinner for two men at threepence each. Australian mutton at fourpence halfpenny a pound and two vegetables would provide a dinner for two men at fourpence each. Australian hare at threepence a pound, with the usual accompaniments, would provide dinner at fourpence per head. Irish stew, made from cheap cuts of meat, and the usual vegetables, can be made to provide a dinner at twopence per head. With such foods a person can live on fourpence to sixpence per day. Poor people do not suffi-

ciently appreciate the legumes. These vegetables are valuable sources of protein; they are not so easily or well digested as meat; but they should be used whenever meat cannot be obtained in sufficient quantity. A comparison of experiments in digestion show that a pound of peas or beans yields as much digestible protein as a pound of meat. Peanuts are a valuable source of protein, and should be consumed more freely than they are usually.

Dietaries for Special Cases—*Hæmoptysis.*—In slight cases no alteration of the food is required. But when there is severe bleeding, the diet must be temporarily reduced to a very small quantity. On the first day cold milk only should be given, a mouthful at a time, out of a feeding-cup; in this way 20 to 30 ounces will be taken in a day. The milk may be iced; small pieces of ice may be given to suck; and the mouth should be washed out occasionally to check thirst. On the second day, the diet should be about the same, adding only two teaspoonfuls of meat-juice every three hours. Third day: The milk may be given lukewarm, about five ounces every three hours; total 30 ounces. A raw egg may be given in ½ pint of milk, divided into two meals. Cold toast, buttered well, 4 ounces; and scraped raw or underdone meat, in sandwiches, 4 ounces, will make a sufficient dietary. From this day there should be a gradual return to the former diet, the patient being fed every two hours with milk, raw eggs, raw-meat sandwiches, cold buttered toast; Benger's, Allenbury's, or Savory and Moore's food; jelly; pounded chicken, light fish (sole or plaice), custard, junket, sago or tapioca pudding, etc. The ordinary diet should be resumed in a week.

Laryngeal Tuberculosis.—Dysphagia often prevents the patient from taking an adequate amount of food. Everything should be given warm, neither hot nor cold. Condiments like pepper and mustard cause irritation. Sometimes soft foods are swallowed better than liquids. The food should then consist of custard, junket, jelly, scraped meat, chicken panada, pounded fish, scrambled eggs, blancmange, Benger's or Savory and Moore's food, jelly, boiled bread and milk, sago or tapioca pudding, milk solidified with gelatin or isinglass, etc. When liquids only can be swallowed, the patient may find it easier to draw them through a tube while lying on the side or in a prone position, the vessel being placed lower than the head. In this way he may take milk, milk and raw eggs, milk and casein or fortified by dried milk, thin arrowroot, Benger's, Mellin's, Savory and Moore's foods, Hygiama, Ovaltine, extract of meat, rich soups (containing eggs and cream), meat-juice, somatose, meat powders, soup thickened with lentil flour, potato soup, boiled bread beaten with a fork and taken in milk, etc. It should be quite easy to provide 160 to 190 grammes of protein, 200 grammes of fat, and 250 to 300 grammes of carbohydrate. Four pints of milk yield 1,600 calories; three raw eggs, somatose, arrowroot, and invalid's foods would make up the dietary.

Vomiting and Dyspepsia in Tuberculous Patients.—Vomiting after food is sometimes very troublesome, and it is usually due to cough-

ing. It is better to have a cupful of beef tea or hot milk to encourage expectoration before the meal, and the vomiting will cease. Sometimes the patient suffers so much from dyspepsia that the large meals prescribed for ordinary cases have to be stopped for a short time. We may then give a diet in which meat or milk form the main items:

6.30 *a.m.*—Half-pint of milk, Ovaltine or Hygiama food.

Breakfast, 8 *a.m.*—Steak, fish, bacon and eggs, toast (dry) with butter; 1 pint of milk-tea, milk-coffee, or peptonized milk.

11 *a.m.*—Leube's soluble meat, raw-meat soup, meat powder in soup, or raw eggs and milk.

Dinner, 1 *p.m.*—Light fish, minced meat, grilled steak or chop, dry toast; custard jelly, light pudding, and stewed fruit.

Tea, 5 *p.m.*—Cold toast and butter, biscuit, milk-tea or milk-coffee.

Supper.—Same as dinner.

Bedtime.—Milk or a glass of good wine.

In severe cases, the diet should consist largely of milk, given every two hours; it may be fortified by the addition of cream, dried milk, Plasmon or Sanatogen; and alternated with raw egg and milk, raw meat in soup, scraped meat sandwiches, custard, junket, milk-jelly, invalid's food—*e.g.*, Benger's arrowroot and milk, peptonized milk.

Tubercular Peritonitis and Intestinal Tuberculosis.—The diet should be of the same character as in other cases of tuberculosis, care being taken to avoid irritation of the mucous membrane and distension by flatus. Meat, rabbit, fowl, or fish, should be scraped, minced, or pounded. Some raw scraped meat may be given. Eggs should be given raw, poached, lightly boiled, or scrambled; in custard, omelette, or soufflé. Milk is valuable when there are no ill-effects from its use; if it causes constipation, it must be combined with a farinaceous food—*e.g.*, Ridge's, Neave's, Savory and Moore's, or Benger's. If it causes diarrhœa, milk should be pancreatized or thickened with arrowroot and flavoured with cinnamon or nutmeg. Casein preparations often cause diarrhœa, and should be carefully watched. Milk puddings containing eggs are useful, and leave very little residue to irritate the bowels. Macaroni is useful, and may be flavoured with grated cheese. Raw meat can be given in soup or sandwiches. Stale bread, dry toast, and biscuits may be given; but the food should not contain too much starch or sugar, lest we cause fermentation and flatulent distension. Tea, coffee, and pancreatized cocoa are useful stimulants and flavouring agents. The following diet-sheet may serve as an example:

6 *a.m.*—Milk 4 ounces with Bovril, or Brand's essence, Wyeth's beef juice, etc.

8 *a.m.*—Two eggs, poached, boiled or scrambled; a rasher of fat bacon; toast, white bread or roll, 2 ounces; butter; tea or coffee with ½ pint of milk.

11 *a.m.*—Soup 5 ounces mixed with 14 ounces of scraped raw meat; *or* raw-meat juice 1½ ounces, with port wine 1½ ounces, and sponge-cake or biscuits.

1 *p.m.*—Minced or pounded cooked chicken, fish or tongue, or underdone beef or mutton, 4 ounces; potato purée with cream or butter, two tablespoonfuls; dry toast or rusk 1 ounce; milk pudding, custard, or junket, a

good helping, with 1 ounce of cream or savoury custard, or macaroni and cheese; glass of milk to drink.

3 *p.m.*—Raw-meat juice, 1½ ounces; port wine, 1½ ounces; *or* Leube's soluble meat.

5 *p.m.*—A poached egg, bread-and-butter 2 ounces, and tea made of milk; *or* ½ pint of Benger's or Allenbury's food.

7.30 *p.m.*—Fish or underdone meat, chicken or tripe, 4 ounces; potato purée with cream or butter; milk pudding, custard, jelly, etc.

10 *p.m.*—Benger's, Allenbury's, or Savory and Moore's food, ½ pint.

It should be observed that ordinary soup and beef-tea are liable to cause diarrhœa, but they do not always have that effect when thickened with flour, and they may be the vehicle for giving meat powder or somatose. Potatoes are laxative sometimes, and must then be forbidden, their place being occupied by dry toast or rusk. Oatmeal, turnips, carrots, cabbage, etc., should be forbidden.

Tuberculosis of the Kidneys or Bladder.—The dietary should be much the same as for tubercular peritonitis. But it is necessary to watch the effect of proteins by frequently examining the urine for albumin and pus. So long as the above diet does not increase albumin or pus, it should be continued; but if it is found to do so, we must confine the patient to milk, bread and milk, milk puddings, invalid foods, tea, coffee, and once a day an egg, fish, chicken, or meat (pounded, scraped, soufflé, or rissole), with potato and a light vegetable. Bread-and-butter may be allowed; also oatmeal, and casein preparations.

CHAPTER XXI

THE NERVOUS SYSTEM

Neurasthenia.—The causes of neurasthenia were divided by Savill into (1) toxæmia, (2) malnutrition, (3) fatigue, (4) shock and trauma. The most popular theory of to-day is that neurasthenia is due to alimentary toxæmia—absorption from the alimentary canal of toxins which gradually pervade the organism, including the nervous system; a subsidiary theory is that by an unexplained selection the toxins primarily affect the neurons. The toxæmia may be due to protein decomposition, impaired metabolism, errors in diet—*e.g.*, the ingestion of too much protein, fat, sugar, alcohol, tea, tobacco—atonic dyspepsia, hyperchlorhydria, constipation, chronic appendicitis, mucous colitis, gastroptosis, enteroptosis, coloptosis, etc. Overwork is an undoubted cause of neurasthenia; and there are two chief theories of the cause of fatigue—viz. (1) auto-intoxication by the waste products of the cells, and (2) exhaustion from excess of work. Shock or trauma may suddenly cause neurasthenia.

Treatment.—In *traumatic* cases a "rest cure" of six or eight weeks' duration is the best treatment, especially when the chief features are headache, loss of memory, nervousness, tremors, palpitation, tachycardia, mental depression, etc. The rest in bed should be absolute for the first two weeks, and ought to be combined with isolation from friends, exclusion of visitors, letters, newspapers, etc. Overfeeding and massage should be resorted to. In *fatigue*, or cases of nervous breakdown, a "rest cure" is again the obvious course to follow. It is, however, often difficult to persuade patients of its necessity until the breakdown is complete. After two weeks in bed and milk diet, the patient should be ordered a course of good feeding, followed by change of air, scenery, and company, and prolonged rest from employment. When neurasthenia follows *infectious diseases*—influenza, etc.—the nutrition of the patient will be much improved by enforced rest, extra food, and freedom from strain. When typhoid fever affects neurasthenics, a marked improvement in their condition follows the prolonged care, nursing, and dieting; this improvement is partly due to the alterative effect of the disease, the increased metabolism, and subsequent rebuilding of the tissues; the trophic power of the nervous system is on a higher level after convalescence than before the fever.

In neurasthenia due to *toxæmia* the most obvious symptom is chronic fatigue. Herter found indicanuria in 65 per cent. of his

cases of neurasthenia. The treatment should be started by full milk diet, combined with the rest cure, to promote the elimination of toxins. The amount should be 4 pints of milk a day, beginning with 3 ounces every two hours, and gradually increasing the dose until 10 ounces are taken every three hours. Milk is valuable as an eliminator of toxins, for its scanty residue, and ease of digestion. It may be disagreeable to some patients, but it usually becomes acceptable when hunger arises and no other food can be obtained. Therefore, milk diet should be absolute for ten days. After this period we may cautiously add other foods—*e.g.*, a boiled or poached egg with bread-and-butter for breakfast, and some fish for the midday meal. As the amount of solid food is increased, the milk may be decreased, taking care that the dynamic value of the diet is not lessened. On the contrary, the diet should be raised in value until the patient is overfed.

The following is a sample dietary:

First Breakfast, 7.30 *a.m.*—A breakfast-cupful of hot milk.

Second Breakfast, 8.30 *a.m.*—Two eggs, boiled or poached, bread or dry toast, and butter; China tea made with ½ pint of milk.

Lunch, 11 *a.m.*—Three or four oysters with wholemeal bread-and-butter, *or* raw-meat sandwiches; a tumblerful of milk.

Midday Meal.—Six ounces or more of fish, fowl, tender beef, or mutton; potatoes, light green vegetables; custard, junket, egg-snow, cornflour mould, stewed fruit, or fresh fruit.

5 *p.m.*—China tea made with milk; oysters or raw-meat sandwiches.

Evening Meal, 7 *to* 8 *p.m.*—Tripe with boiled onions; fish, fowl, rabbit or tongue with bread-and-butter; fresh fruit; milk and cocoa.

Bedtime.—A tumblerful of milk.

Oatmeal.—Decalcification is common in neurasthenia; the urine frequently contains an excess of calcium carbonate and phosphate. Meat and oatmeal are decalcifying agents, and it would seem *a priori* that these foods should be excluded. But it would not do to deprive the patient of the stimulating properties of meat, except during the preliminary period of absolute milk diet. Oatmeal may be excluded for a time if the patient is not progressing favourably. In every case a large amount of milk ought to be taken, and it is probable that some of the benefit derived from this food is due to its richness in lime and lipoids.

The nitrogenous metabolism is sluggish in this disease; therefore a stimulating diet is essential. The consumption of a large amount of protein will accelerate the metabolism. Although they have the same dynamical value, a pound of protein causes greater chemical changes in the body than a pound of carbohydrates. But they do not contain an equal amount of carbon, and therefore "mixed diet" is essential. When the muscles are wasted, a properly balanced diet, containing a small excess of protein (say 2 grammes of protein per kilo), combined with rest and massage, is sufficient to rebuild the muscular tissues, and promote the recovery of the nervous system. The effect of certain bodies in food, called *vitamines*, is not yet clearly known, but there is no doubt that whole-

meal bread, germ bread, and bread containing malt-culms, are more stimulating than ordinary white bread, and promote greater cellular activity. Lecithin is an important element of nerve tissues. But we cannot always rely upon beneficial results following the use of lecithin-containing foods. It would seem that the yolk of eggs, the brains of sheep and pigs, and similar foods ought to be extremely valuable. And so they are in many cases. But lecithin is sometimes decomposed in the bowels, and causes toxic symptoms. If it is known, therefore, that these foods disagree with the patients, their use should be forbidden. There is evidence, however, that the inorganic phosphorus of the food is almost incapable of being assimilated by the nerve cells; but lecithin and its compounds bring to the nerve cells highly phosphorized organic substances, ready to be built into the complex molecules of nuclein. Maize probably contains more lecithin than any other vegetable food, and may be taken as hominy or porridge. Milk also contains lecithin. The lecithins are either absorbed unchanged, or decomposed in the bowels into cholin, neurin, and glycerophosphoric acid, and resynthetized into lecithin by the absorbing cells; neither lecithin nor glycerophosphoric acid have been found in the urine or fæces. Respecting cholesterin, another constituent of nerve tissues, we do not know exactly what rôle it plays in metabolism (see Vitamines). It is one of the substances which are essential to the well-being of the organism, being present in all living cells, and therefore those foods containing it should be prescribed for the neurasthenic. Especial mention should be made of carrots, peas, and beans, which may be given in alternation. Carrot soup is valuable for such persons.

All vegetables are beneficial to neurasthenics if they do not overtax the alimentary organ. But a few vegetables are said to be particularly valuable to them—*e.g.*, onions, garlic, shalots, chives, leeks, watercress, mustard and cress, horseradish, and spinach. These foods are stimulating primarily to the digestive organs, and secondarily to the nervous system. They should be forbidden to patients having erotic tendencies. The latter remark also applies to celery and asparagus, which are useful in ordinary cases. Cloves, nutmeg, caraway, and cinnamon may be used as spices in the preparation of food; they have a stimulant effect, and prevent or remove nervous depression and lowness of spirits.

The excessive use of tea, coffee, and cocoa ought to be prohibited. China tea may be allowed, but milk should form the principal beverage.

The **Weir Mitchell** treatment was designed for serious cases of neurasthenia and hysteria. The following are the essential items: (1) The patient is put into a nursing-home; (2) the nurse should be a stranger to the patient, young, cheerful, and reliable; (3) isolation is strictly carried out for six or eight weeks—no visitors, no letters to be sent or received, no newspapers; (4) rest in bed must be absolute; (5) diet, the patient is dieted as detailed above: milk every three hours for five or six days; sixth day, a chop or steak at midday;

seventh to tenth days, eggs and bread-and-butter for breakfast; from this time, three full meals daily, besides 3 or 4 pints of milk, and 2 to 4 ounces of extract of malt; (6) massage to be commenced on the third day of rest, and carried out systematically until the end of the treatment; (7) electricity, interrupted faradic current, may be applied to the motor points all over the body for thirty to forty-five minutes daily.

The Weir Mitchell and other overfeeding cures are valuable for neurasthenia; but in the majority of cases there is a great accumulation of fat in the body during the treatment, and this is rapidly lost when the patient returns to ordinary diet and exercise. This is not as it should be. Fat is wanted in the body, but not an excess of it. There is, at the present time, a revulsion against overfeeding. Those who have revolted, however, consider high and generous feeding is essential; but they watch the weight and counteract the evils of overfeeding by extra massage. Some physicians have gone to the opposite extreme. Noël Paton says: "A neurasthenic does not require to be fed like a navvy; in most cases 60 grammes of protein daily is enough, and this would be supplied in a quarter-pound of beef or mutton, and the usual allowance of bread and vegetables." It is, however, an undoubted fact that most neurasthenics are undernourished and have been underfed; and therefore, until the nutrition of the body becomes normal, the food should be something more than normal. There are some cases which do not require absolute rest in bed; the nerves are thoroughly tired out and need rest, but this can be got without isolation and lying in bed: a holiday of sufficient length may be all that is necessary if the food is properly arranged and combined with rest of body and mind. An overworked man may find rest in a long sea voyage, or fishing on the sea while staying at the coast, and the mind may get rest by a change of company combined with walking, golfing, etc.

Hysteria.—The nutrition of the nervous system is deranged in consequence of a failure in the supply or metabolism of food, especially arising from chlorosis, gastro-intestinal disorders, and diseases of the sexual organs. When there is any evidence of disease of the uterus or other generative organs or passages, they must be treated *secundem artem*. But there is no guarantee that the cure of an erosion of the cervix, flexion of the uterus, or disease of any other organ which has been the primary cause of the disorder, will be followed by a cure of hysteria. It is a psychical disorder. The cure of a physical ailment may so impress the patient that the mind will recover its tone. But the cure of hysteria rests very much with the patient; when she makes up her mind to get well, she will get well; but until this exercise of the patient's will is brought about, very little real good can be done. It should not, however, be thought we are without resource. Much can be done even for unwilling patients. The treatment most successful consists in the employment of remedies which influence the nutrition of the system. The greatest benefit accrues to patients whose hysteria depends on chlorosis,

atonic dyspepsia, constipation, and other disorders of the alimentary and metabolic functions by the means detailed under those headings. In very severe cases Weir Mitchell treatment is by far the better method. When isolation cannot be carried out, the patient should be overfed, the diet consisting of milk, meat, poultry, eggs, bread-and-butter, puddings, jellies, custards, creams, fresh vegetables, and fruit. Fish should be excluded from the diet if the patient has erotic tendencies. Tea, coffee, and cocoa should be reduced to a minimum; alcohol should be totally excluded. Moral and disciplinary treatment is required in many cases. Above all, they should be encouraged to work, and especially to work for others; philanthropic work, helping others out of their troubles, materially helps to cure many hysterical patients.

Hypochondria, Melancholia, and Other Mental Diseases.—The treatment, as far as we are concerned, consists in looking after the general health, the condition of the body, and its nutrition. An examination of the tongue, and the alimentary and eliminatory functions will give a clue to the diet which ought to be prescribed. Get these organs into a proper condition, and then feed up the patient. A good cook is as important as a good doctor. As regards the kind and amount of food, we must be guided entirely by the condition of the stomach, the power of digestion, and assimilation. In acute cases there is nothing better than milk or egg-flip—hot milk with raw eggs and sugar. A pint of milk, with two raw eggs and 1 ounce of sugar, will contain 36 grammes of protein and 675 calories; this quantity can be given three times a day. If the patient cannot or will not swallow it, forcible feeding must be resorted to. An œsophageal tube may be used, but nasal feeding is more easily performed; it is done by passing a long rubber tube or No. 12 to 14 rubber catheter through one nostril into the pharynx or œsophagus; the other end is attached to a funnel, and the liquid food slowly poured through it. If this method of feeding has to be kept up very long, the diet must be varied; besides egg-flip, the following may be given: strong soup, vegetable soup, sausage meat made into an emulsion with milk or water and strained through a coarse sieve; meat powder (meatox, Mosquera's beef meal); peptonized gruel; milk powder (Cow and Gate brand); casein preparations, arrowroot and milk, isinglass and milk, liquefied jelly, glucose, wine, fruit juice, etc.

When the patient is able and willing to take food in the ordinary manner, our task is comparatively easy. But the food must be nicely cooked, well prepared, pleasant to the eye, tempting to the palate, and daintily served. The patient must be overfed: three principal meals daily, with intermediate small meals—*e.g.*, a glass of milk, egg-flip, some Sanatogen or Plasmon, a raw-meat sandwich, three or four oysters, etc. The diet given for neurasthenia is applicable. Weir Mitchell treatment is beneficial. But it requires the careful exercise of judgment to determine whether lying in bed is more likely to be beneficial than exercise in the open air. Moderate exercise in the open air is essential at some period of nearly every

mental case, but it may be begun too soon or pushed to excess. Massage is a good substitute for exercise in some cases, in others it is a very poor one. Rest and exercise are not antagonistic; they are complementary, each bringing the right thing at different stages of the same case.

Epilepsy.—The alimentary organs must receive the closest attention. The teeth must be examined, carious teeth stopped, or removed, and vacancies filled by artificial teeth. This simple procedure alone in many cases has reduced the frequency of the fits by improving mastication and digestion. In like manner due attention must be given to the stomach, liver, and bowels, for, when the teeth are good, a reduction in the number or frequency of fits is produced thereby; and, on the contrary, indigestion, constipation, and hepatic insufficiency will increase the frequency of the attacks.

Various dietaries may be adopted: (1) Ordinary mixed diet, (2) vegetarian or lacto-vegetarian, (3) purin-free, (4) and salt-free diet.

1. *Ordinary Mixed Diet.*—All those articles forbidden in gastric and hepatic disorders (*q.v.*) are equally unsuitable for epileptic persons. A sufficiency of food must be allowed, but it ought not to exceed his normal requirements. A close watch ought to be kept over the amount of meat and other animal foods consumed. Most epileptics are big eaters, and often bolt their food. They should be persuaded to eat slowly and to masticate their food carefully. They should have four meals a day—breakfast at 8 a.m., dinner 12.30 noon, tea 4.30 p.m. (a very light meal), and supper at 8 p.m. (also a light meal). Butcher's meat and poultry must only be allowed at the midday meal; fat bacon, fish, or an egg, may be taken for breakfast, and occasionally for supper. Eating between meals, especially taking chocolates, candy, and other confections, should be forbidden. At the Chalfont Epileptic Colony the meals are as follows:

Breakfast.—Oatmeal porridge with new milk and sugar; bread-and-butter, and tea.

Dinner.—Mutton or beef (roast, boiled, or minced); fish on Friday; potato, cabbage, or other vegetable; jam-roll or suet pudding and cooked fruit, alternately with milk puddings (rice, sago, or tapioca).

Tea.—Tea, bread-and-butter, sometimes treacle or cake.

Supper.—Milk pudding, bread and milk, or thick soup alternately.

At Bielefield and Craig Epileptic Colonies the food is similar. Many patients arrive at these institutions in poor health. The object of treatment is to build them up by the adoption of broad general principles. Of course, special feeding is required in some cases. When the patient is very feeble he is put into hospital and given a very light nourishing diet, consisting mainly of milk and milk foods. If he arrives in moderate health, he is put on diet such as that of Chalfont. He is not allowed to overfeed himself, although he is permitted tobacco, tea, and coffee (well prepared) in moderation.

2. *Vegetarian or Lacto-Vegetarian Diet.*—Most epileptics are very fond of animal food, and, in some cases, the frequency and violence of the fits bear a proportion to the amount of meat consumed. An

excess of animal food is admitted on all hands to be injurious, but there are some physicians who find a vegetarian or lacto-vegetarian diet is curative; that under its influence the fits cease, and remain absent so long as the patient avoids eating meat, fish, poultry, and eggs. It is also found that when vegetarian diet is consumed, a smaller dose of bromide is sufficient to restrain the attacks. My own experience is that lacto-vegetarian diet is far better than a purely vegetarian diet, and I am strongly of opinion that the frequency of the attacks gradually diminishes until they vanish. A purely vegetarian diet is not suitable for epilepsy. The malnutrition and depression of epileptics is due to gastro-intestinal indigestion, which might be aggravated by a purely vegetarian diet, but would be improved by a combination of vegetables, milk, and eggs.

3. *Purin-free Diet.*—It was shown by Krainsky[1] that there is a close connection between the excretion of urea and the occurrence of fits. So long as the excretion of urea averages 0·6 to 0·8 gramme per fluid ounce of urine, there is no danger of a seizure; but each attack is preceded by a diminution of the urea, and when it falls to 0·45 or 0·35 gramme per ounce a seizure is imminent. An injection of carbamate of ammonia produces exactly similar seizures, whence Krainsky concluded that epileptic seizures are due to a failure in the transformation of nitrogenous substances to urea, and reduced the allowance of proteins. Haig[2] believes the fits are due to the accumulation of uric acid or purin bodies owing to a failure of the organism to transform these substances to urea, and prescribes purin-free diet. Aldren Turner[3] finds in confirmed epilepsy that the combination of purin-free, salt-free, and vegetarian diets is very beneficial, and he prescribes the following:

Milk (fresh or sour), buttermilk, whey, cheese. Eggs, raw, boiled, or scrambled. White bread, macaroni, vermicelli, semolina, rice, sago, and tapioca. Suet puddings with jam or treacle, apple dumplings, pastries, pancakes, tea-cakes, jellies. Vegetables and fruits of all kinds; weak infusion of tea; water.

Turner's results from this diet are so good that he recommends it for all recent cases of epilepsy, and says: "In all cases in which bromide alone has been of little or no use, the purin-free and saltless diet has at once led to material improvement. By its aid less bromide is required, and if the patient loses weight under its influence, the addition of cream or cod-liver oil is usually sufficient. If this is not sufficient, it is advisable to permit fish, or even a little lamb or mutton."

4. *Salt-free Diet.*—The nervous system is rendered more susceptible to the action of many drugs by depriving the system of sodium chloride. A patient on a salt-free diet requires a smaller dose of bromide to produce the desired effects, and bromism is less common than with an ordinary diet. Hoppe-Seyler says the effective control of epilepsy only occurs when one-third of the chlorine of the blood is replaced by bromine. Landenheimer found that a proper thera-

1 "Mémoires Couronnes," 1901. 2 "Uric Acid," 1892, p. 15.
3 "The Morrison Lectures on Epilepsy," 1910.

peutic effect is only obtained when the intake and output of bromide salts balance each other. Bromide saturation occurs earlier with salt-free diet—viz., in three or four days—while an ordinary diet requires three or four weeks to produce the same effect. With ordinary diet the patient may take bromide for years without the occurrence of toxic symptoms, but with a salt-free diet the saturation point is lowered, and, if any cause should check the excretion of bromide, there may be a sudden development of bromism.

Bálint and others state that bromism never occurs when the diet is properly arranged—*e.g.*, milk $1\frac{3}{4}$ to $2\frac{1}{2}$ pints, bread $9\frac{1}{2}$ to 12 ounces, butter $1\frac{1}{4}$ to $1\frac{1}{2}$ ounces, three eggs, tea, coffee, sugar, and sufficient fruit and vegetables to bring the food value up to 2,300 or 2,400 calories a day. If all these foods are cooked without salt, the diet will only contain 2 grammes, or, roughly 30 grains, of sodium chloride daily. The bread can be made with yeast and salted by mixing sodium bromide with the flour, the proportion being so arranged that a loaf for one day contains 45 grains of sodium bromide. Such bread is called *Bromopan*. Other examples of salt-free diet are given in the chapter on Bright's disease. This diet should be given for 5 or 6 weeks at a time. Sodium bromide can be used as a condiment like common salt.

Chorea.—The patient should be kept in bed to insure complete physical rest and prevent cardiac complications; mental rest is equally essential. The patient should be well fed. Milk, eggs, fish, scraped meat, chicken cream or panada, tripe, tongue, oysters, and other easily digested protein foods should form the basis of the diet. An excess of farinaceous, and especially sweet foods, should be avoided. In fact, the diet should be the same as for anæmia or hyperchlorhydria, the patient's age being taken into account.

A girl of twelve years might have—Milk 2 pints; meat, fowl, or tongue 4 ounces; bread or toast 4 ounces; potato 3 ounces; one egg, poached, boiled, or in custard; this would contain—protein 60 grammes, energy 1,320 calories.

A diet consisting entirely of milk and eggs would not be correct for an anæmic child. Moreover, no nervous disease is more likely to be fostered by alimentary toxæmia than chorea; the remarks on this subject in the article on Neurasthenia are applicable to it. If there is a very pronounced toxæmia, as shown by indicanuria, the protein content of the food should be lowered for a time. It will then be necessary to prescribe a larger quantity of carbohydrate and assist its digestion by giving extract of malt, takadiastase, or pancreatic powders. Where there is very great irritation of the stomach, it may be necessary to suspend gastric feeding and resort to rectal feeding for a few days.

When the gastro-intestinal functions have been re-established, the food will require further consideration. The food must be well balanced. The reader should consult the tables of requirements on pp. 165-167.

Siegert pointed out that children, between the ages of three and ten years, who take too much albumin and fat, and too little carbohydrate, cellulose, and alkaline salts, develop a distrophy indicated by a pale or yellow complexion, loss of appetite, emaciation, con-

stipation, and nervousness. Chorea is fostered by such a condition; therefore carefully regulate the diet. Some authorities consider red meat is too stimulating for a choreic child. But, as a general rule, any child over three years of age should have meat once a day—butcher's meat, fowl, or fish—and it may be scraped, minced, or cut into thin strips to assist mastication. Careful mastication must be insisted on—it is often overlooked by the mother or nurse. Eggs, providing they are fresh, are proper food; they may be given boiled, poached, or in milk pudding or custard. Fruit, vegetables, salads, wholemeal bread, and oatmeal, are essential elements of the diet if children can masticate and digest them. Siegert objects to cocoa, chocolate, and legumes for all nervous children; but the only obvious reason is from the point of view of digestion. Tea and coffee ought to be withheld. The importance of lime in the food of convulsive subjects has been commented on elsewhere; sufficient is contained in the milk and other foods. Warm baths, followed by a shower bath, or sponging with cold solution of sea-salt, and massage of the limbs, are beneficial. Graduated exercises, gymnastics, change of air, constant galvanic current to the spine, and moral discipline are useful aids to recovery.

Neuritis, Multiple Neuritis, Sciatica, Neuralgia.—In the majority of cases of **local neuritis,** neuralgia, sciatica, etc., it is sufficient as regards diet to prescribe light nourishing food, taking care that such food does not upset the digestive and metabolic processes. When it is known that indigestion, gastro-intestinal catarrh, hepatic hyperæmia and insufficiency, or other disturbance of metabolism exists, the diet must be that of the associated condition. Alimentary toxæmia must be treated. Gout, rheumatism, or diabetes, may be associated with the disease. The abuse of alcohol must be forbidden in all cases. An occupation leading to mineral poisoning ought to be abandoned. Weakly patients should guard against fatigue, overwork, and mental depression. In **multiple neuritis,** alcoholic paralysis, etc., the treatment should be started by putting the patient to bed and giving absolute milk diet for ten to fourteen days. After this preliminary dietary, the organism should be built up by overfeeding—*e.g.*, Weir Mitchell treatment—but isolation is unnecessary, except when the mental condition demands it. If the appetite is poor, feed with milk, raw eggs, custard, creams, farinaceous foods, chicken panada, fish cream, light fish, oysters, jellies, soups, milk puddings, etc. In alcoholic cases a careful watch must be kept over the visitors, and this may necessitate the exclusion of those who surreptitiously supply it. The free use of simple liquids, the diuretic action of milk, mild purgation, hot baths, and massage are useful for assisting the elimination of toxins.

Apoplexy, Hemiplegia, Locomotor Ataxy, and Other Paralyses.—A case of apoplexy needs care from the physician and nurse. If the period of unconsciousness is short—twenty-four to forty-eight hours—no food is required; but care should be taken that the urine

is drawn off regularly, and the colon emptied by croton-oil applied to the tongue, or an enema of soapy water. The patient will derive comfort if the mouth is sponged occasionally and the tongue moistened with glycerine. If the consciousness is of longer duration, rectal feeding should be resorted to (pp. 318-325). When the patient has recovered consciousness and is able to swallow food, he should be given a low diet. On the first day of feeding he should have about 1½ pints of milk in small quantities, diluted with an equal amount of barley-water. The second day, 2½ pints of milk, and some Benger's food, may be given; sugar should be freely used. The third day the food may consist of 2 or 2½ pints of milk, two raw eggs, some Benger's or other farinaceous food. From this time a light unstimulating diet must be the rule—*e.g.*, milk, bread-and-milk, farinaceous foods, custard, junket, jelly, and thin sago or rice pudding. The future dietary should be that detailed under Arterio-Sclerosis.

In hemiplegia, paraplegia, locomotor ataxy, and other paralyses, the diet must constantly be light, nutritious, and not very stimulating. The amount of protein should not exceed 80 grammes daily, and in aged persons it may with advantage be reduced to 60 grammes. The total food should also be rather low, say, 2,000, 1,800, or even 1,600 calories, according to age and other circumstances. Animal food should be restricted to a small helping of meat, rabbit, fowl, or fish, in the middle of the day. Fat is not prohibited by any authority; on the contrary, it is beneficial and checks the craving for lean meat. Therefore butcher's meat should be fat, and cold boiled ham or bacon should be given with fowl or rabbit. A small helping of fat bacon or ham may be eaten for breakfast. Tripe, tongue, oysters, eggs, vegetable soups, and all kinds of soup, fresh vegetables, and fruit may be eaten. Bread-and-butter, milk puddings, oatmeal porridge, farinaceous foods, and stewed fruits may all be eaten. Rich foods of all kinds should be forbidden. All foods forbidden in gastric or intestinal catarrh and hepatic hyperæmia should be excluded. Especial care must be taken of the alimentary organs. Gastric crises are very liable to occur, particularly in ataxic patients with changes in the joints. Eichhorn[1] distinguishes three varieties of gastric crises besides mixed forms—(1) Neuralgic or sensory form without vomiting: there is severe pain, increased by light pressure, but often relieved by deep pressure over the stomach; (2) hypermotor or spasmodic form, distinguished by vomiting and severe pain in the stomach; and (3) the secretory form, characterized by vomiting much watery fluid having an acid reaction, but containing little HCl. During such crises the patient should be treated as if he were suffering from acute gastric catarrh. The return to the previous dietary should be very slow. An inquiry into the patient's habits and diet may reveal something which accelerates or accentuates the crises.

[1] *Wien. Med. Klin.*, September 12, 1909.

Headache, Migraine.—Diet is of great value in curing chronic headaches and even migraine. But it is exceedingly important that the cause of headache or migraine should be diagnosed.

Harris[1] classified them as follows: **Superficial headache** due to (1) diseases of the brain coverings, (*a*) pain in the scalp from cellulitis, weight of a hat or mass of hair, (*b*) pain in the pericranium from rheumatism or syphilis, (*c*) pain in the bone from caries; (2) reflex visceral neuralgia originating in the condition of the eyes, teeth, lungs, heart, stomach, bowels, etc. **Deep headache** due to (1) reflex cortical neuralgia—*e.g.*, visual "academy" headache, thunderstorm and neurasthenic headaches; (2) toxæmic headaches arising from constipation, sluggish liver, influenza, fevers, alcohol, ether, foul air; (3) increased intracranial pressure—*e.g.*, migraine, epilepsy, tight neck-band, cerebral œdema due to chlorosis or arterio-sclerosis; hydrocephalus; sinus thrombosis; cerebral hæmorrhage; acute encephalitis; cerebral abscess or tumour.

The diversity of causes shows how impossible it is to treat all headaches alike. **Migraine** was divided by Liveing into—(1) Simple hemicrania, a typical unilateral headache, throbbing with every beat of the pulse, and recurring every few weeks; (2) sick headache, a periodical unilateral headache, culminating in nausea, vomiting, and prostration; (3) blind sickness, the headache being accompanied with blurring of the vision, and appearance of luminous zigzags or fortification figures.

There is no doubt that many headaches are due to alimentary toxæmia arising from intestinal putrefaction, hepatic insufficiency, and other disturbances of the metabolism. As regards the liver, Brunton says: "The liver is the porter which stands at the gate of the organism to prevent all deleterious substances which enter the bloodvessels from the intestines from reaching the general circulation. These substances are caught up by the liver and destroyed, or excreted unchanged into the intestine, where they may pass away with other fæces. But many of these substances may be reabsorbed, and so they form a constant round from bowel to liver and liver to bowel, until at last they amount to so much that the liver cannot deal with them, and they pass into the general circulation. A period of time is required for this accumulation, which varies even in the same person, and occurs in less time with a highly nitrogenous diet. Absorption from the liver is influenced by the emotions, so that after emotion a person may become jaundiced; therefore we may expect anything which is circulating with the bile would be rapidly absorbed. Anxiety, grief, or sorrow, is apt to bring on a headache, and there are good reasons for attributing the headache to the presence of abnormal constituents circulating in the blood. Why do the toxins fasten on the head and cause a headache instead of causing a pain in the intestines or big toe? It is because there is some factor, perhaps a local lesion, which determines the pain to the head. The most common determining causes are decayed teeth, astigmatism, myopia, hypermetropia, presbyopia, nasal or pharyngeal trouble, disease of the

[1] *Brit. Med. Jour.*, 1908, ii.

antrum of Highmore, or of the frontal or ethmoidal sinuses, glaucoma, periostitis, or neuritis."

The treatment of headaches therefore includes the treatment of the cause. This should be carefully diagnosed. As regards diet, some patients require feeding up, others require a reduction of flesh, and both classes probably require their diet rearranging to suit the present conditions. There is no method of feeding which will suit all cases, excepting this: the food must be light, nourishing, and digestible. All the articles forbidden in gastric, intestinal, and hepatic disorders should be forbidden in the treatment of this disease. Most cases require plain simple diet of the ordinary kind; but some patients need a reduction in the amount of starch and sugar; others are decidedly benefited by a lacto-vegetarian and purin-free diet, and in other cases the Salisbury diet has proved the only satisfactory cure. Haller cured himself of migraine by a light diet and a large amount of water. Marmontel likewise cured himself by eating little, drinking much water, and taking plenty of exercise. Bilious headache is often the result of an excessive consumption of sugar or sweet foods (cakes, puddings); the excess of carbohydrates, being imperfectly metabolized, set up that condition called "hyperpyræmia," or, being transformed to lactic acid, irritates the vagus, and sets up bilious attacks with distressing migraine. Such cases are benefited by reducing carbohydrates to a minimum, or even giving Salisbury diet, until the power of digesting and metabolizing carbohydrates is recovered.

On the other hand, migraine is sometimes a consequence of imperfect nitrogenous metabolism. The urine contains an excess of purins, ethereal sulphates, or indican. In these cases it is reasonable to suppose relief will follow restriction of proteins. But it may be that it is an excess of carbohydrates that interferes with the metabolism of proteins. It is absolutely certain the majority of female sufferers from migraine do not consume an excess of animal food; indeed, many of them do not eat enough of any kind of food. The golden rule in such cases is simplicity of diet combined with careful mastication and daily evacuation of the bowels. The idiosyncrasies of the patient should be studied; eggs, fish, fowl, or butcher's meat may be each a poison to some migrainous patient. Whatever is known to disagree should be excluded. A long course of lacto-vegetarian or fruitarian diet, which is practically purin-free, is the only remedy for some cases. The dietary which I have found beneficial has the following basis:

Milk, 2 pints; bread, 6 ounces; oatmeal or pearl barley, 1½ ounces; macaroni, 1½ ounces; cheese, 1½ ounces; butter, 2 ounces; fat bacon (*fried*) or boiled fat ham (*no lean*), 2 ounces; shelled nuts, 3½ ounces; fresh fruit and vegetables *ad libitum*; sugar, honey or treacle, 1½ ounces. The total protein is 100 grammes, the energy 2,800 calories; enough for a working man.

The milk should not be less than 2 pints a day, and this will provide 40 grammes of protein. It may be taken hot or cold, in junket or jelly, or macaroni pudding. Being assured that this

quantity of milk is consumed, we may be confident that, with other foods, the patient will not suffer protein starvation from the absence of animal food. Although the patient is not allowed lean meat, there is no reason why he should not eat meat-fat, therefore fat bacon, fat ham, and suet puddings are good foods. A palatable dish may be made of boiled fat bacon, boiled macaroni, tomatoes, and grated Parmesan cheese. Nuts have the same protein value as meat, but fruit and vegetables must be eaten the same day as nuts to prevent constipation. The following combinations are suitable: Apples, walnuts, and figs; apples, dates, and roasted peanuts; apples and raisins with walnuts or peanuts; apples, almonds, and bananas; grapes or raisins, Brazil nuts or filberts; oranges, bananas, and filberts, etc.

CHAPTER XXII

FEVERS

THE constancy of the temperature of the body is remarkable. The temperature of the interior is somewhat higher than that of the skin, but the mean is maintained by the circulation of the blood, radiation of heat, and evaporation of moisture from the skin. The production of heat is increased by muscular action, and diminished by rest. Loss of heat is increased by dilatation of the cutaneous vessels and increased flow of blood through them; it is diminished by contraction of the cutaneous vessels and dilatation of those in the splanchnic area. These variations are normally controlled by a thermotoxic mechanism in the cerebral nervous system, and there are trophic or nutritional nerves which likewise influence anabolism and katabolism, and thereby the production of heat.

In fever the production of heat is increased 10 or 12 per cent. The rise of temperature is due to a combination of causes—(1) Disturbance of the heat-regulating mechanism; (2) increased production; and (3) diminished loss of heat. Increased production of heat only causes rise of temperature when the heat-regulating mechanism is disturbed.

The metabolism is greatly increased during fever. The intake of oxygen and output of CO_2 are increased about 20 per cent., owing to increased oxidation. With the decline of fever, the intake of oxygen and output of CO_2 sink to normal, or less than normal, owing to reduction of oxidation. The excretion of nitrogen is increased 20 to 50 per cent. during fever, owing to destruction of the tissues.

In a healthy body the nitrogen excretion is proportioned thus: Urea 84 to 87, ammonia salts 2 to 5, uric acid 1 to 3, extractives 7 to 10 per cent. The urea group (urea, creatin, and ammonia) is derived from protein in general; the purin group (uric acid, xanthin, hypoxanthin, adenin, etc.) from nucleins and nucleo-proteins only. In fever, all the nitrogen is increased, but particularly the uric acid and ammonia. That this increase arises from the destruction of body tissues is shown by the ratio of phosphoric acid to the nitrogen in the urine. In meat the ratio of P_2O_5 to N is 1 : 7·3; when a body is fed on meat the ratio in the urine of P_2O_5 to N is 1 : 7·3 or 6·9. In tissue protein the ratio of P_2O_5 to N is 1 : 3·9 or 4·1; during starvation and fever the ratio of these bodies in the urine is the same as in tissue protein.

Feeding the Patient in Febrile Conditions.—The custom of "starving a fever" prevailed for centuries. This was changed by Graves (1840 to 1850), who "fed fevers" and urged the necessity for a rational diet. Since that time many observations on metabolism

in fever have been made. These observations, speaking generally support Graves's contention that fever patients formerly were insufficiently fed, and the diet ought to be arranged on a physiological basis. It was formerly contended that food causes an increase of fever, but recent observations disprove that dogma. In 1892 Puritz experimented on fever patients with (1) low diet, (2) abundant diet, and (3) diet containing a normal proportion of protein and an increased amount of fat and carbohydrate. The *abundant diets* did not cause any increase of fever; they consisted of meat, milk, bread, port wine or brandy, and included—protein 180, fat 60 to 90, and carbohydrate 300, grammes. The low diets consisted of broth, milk, bread, wine or brandy, and included—protein 40, fat 10 to 20, and carbohydrate 100 to 120, grammes. The digestion and assimilation during fever were found to be somewhat below normal. But when the patients took a large amount of liquids, they digested 78 to 82 per cent. of protein, and during convalescence 85·6 to 90·5 per cent. Hoesslin, after experimenting on cases of typhoid fever, confirmed these statements. He gave the patients milk, eggs, soups, porridge made with flour, ham, and other foods, and found, when the fever was moderate (100° to 103° F.), and the diarrhœa also moderate, the matter of the fæces was not materially increased, and the digestion and assimilation of food did not materially differ from that of healthy individuals. Other physicians have obtained similar results. In severe cases of fever 75 to 82 per cent. of protein, 90 per cent. of fat, and 85 to 90 per cent. of carbohydrate is digested and assimilated.

It is therefore not correct to say it is useless to give a fever patient foods because they are not properly digested. The effect of fever is to check the secretion of saliva and gastric juice to some extent. The mouth is dry and the appetite deficient. The secretion of gastric juice is diminished, and the hydrochloric acid absent or much reduced. The digestion is largely intestinal, and that may be defective from the absence of hormones. These are not sufficiently powerful arguments to combat the results of experiments in digestion. It is proper to feed a fever patient in a rational manner. It is probable that the reaction against low diet or starvation for fever was carried too far, and a too abundant diet was given by many physicians. At the present day some physicians have reverted to the starvation diet, but the general tendency is to give a normal diet of liquid and semisolid foods of a light and easily digestible character, with some excess of carbohydrates to spare the destruction of tissues.

A consideration of the metabolism leads to the same conclusions. The observations show that a healthy body absolutely at rest excretes 7 or 8 grammes of nitrogen daily, and when doing moderate work, 11 or 12 grammes daily; but in febrile diseases, such as pneumonia, typhoid fever, diphtheria, etc., the excretion of nitrogen rises to 18 or 20 grammes a day. Therefore more protein is required during fever to protect the cells which are sound, to replace

cells damaged by disease or broken down by oxidation, to supply amino-acids for consumption by the phagocytes, and for the formation of antibodies. Observations have shown that, on a low diet, the nitrogen of the urine may be four or five times as much as the nitrogen in the food, but with an abundant diet during fever the nitrogen in the urine is only 10 or 15 per cent. more than in the food. To meet this increased expenditure of nitrogen during fever, the food ought to contain 1·5 to 2·0 grammes of protein per kilo (0·75 to 1·0 gramme per pound) of body-weight, or a total of 105 to 150 grammes of protein daily. *This is the physiological demand for protein during fever.*

It is possible that nothing will absolutely prevent the waste of tissues or emaciation during fever. One of the causes of emaciation is the increased combustion or oxidation of carbon. The radiation of heat is increased 20 per cent., and this increased heat is derived from the destruction of tissues. So far as the supply of carbon for oxidation is concerned, the tissues can be spared considerably by giving gelatin, fat, and carbohydrates in the food. According to Wicke and Wieske,[1] 100 grammes of starch diminish the katabolism of protein 19 to 21 per cent., and 100 grammes of fat diminish it 30 to 40 per cent.

These considerations allow that the consumption of protein during fever should not be less than normal, and it may, with advantage to the patient, be slightly increased. As the expenditure of energy is increased 20 per cent., the total calorie value of the food ought to be proportionably increased. During absolute rest in bed a healthy man uses 1,400 to 1,600 calories of energy; during fever the expenditure rises to 1,750 or even 2,000 calories. Allowing for the diminished power of digestion during fever, the heat value of the food for an adult should be not less than 2,000 calories, and the protein not less than 100 grámmes per diem. Want of appetite is no proof of inability to digest food. It has been shown in a person with complete anorexia that food, when introduced through an œsophageal tube, is digested as well as in a case of fever. Whether carbohydrate or fat should be given as a protein-sparer partly depends on the patient's liking; fat appears to be more easily digested than carbohydrates during fever, but patients frequently object to butter, cream, and other fatty foods, and take jelly (gelatin), farinaceous foods, and sugars more readily.

The Importance of giving Carbohydrates in Fever.—Although the patient may be allowed a choice of fat or carbohydrates, there are reasons why carbohydrates form a most essential part of the fever diet. When patients are badly fed, their tissues are destroyed rapidly. But during a high temperature the oxidation of nitrogenous tissues is incomplete, and the fatty substances are not reduced to their lowest terms. Indeed, some of the fatty acids do not pass beyond the stage of β-hydroxybutyric acid, diacetic acid, and acetone. In consequence of this imperfect oxidization, there arises

[1] *Zeit. f. Physiol. Chem.*, 1896, xxiii. 265.

a condition of acidosis and acetonuria. It is believed that acidosis is responsible for the "typhoid state." It has been shown, however, that this can be prevented by the administration of carbohydrates. Von Noorden watched its effects in cases of typhoid fever. A was given a diet containing very little carbohydrate, and the urine developed a marked reaction of diacetic acid. B had a diet containing plenty of carbohydrate, and the urine developed only a slight reaction of diacetic acid. The diets were then reversed; the urine of A afterwards gave only a slight diacetic acid reaction, that of B a marked reaction. Similar results have been obtained in other fevers, and show a judicious use of carbohydrates will prevent or cure the "typhoid state." It is not essential that the carbohydrates should consist of starchy foods. The soluble foods containing dextrin, malto-dextrin, maltose, lactose, or saccharose, can be used. These carbohydrates are absorbed during fever almost as completely as in health. The protein-sparing power of disaccharides is about the same as that of polysaccharides (*e.g.*, starch and dextrin), but the polysaccharides take up more energy in digestion than monosaccharides (dextrose, levulose, and galactose).

Moreover, there is another reason for the free use of carbohydrates —viz., the influence of diet on the intestinal flora. The character of the bacteria can be altered by varying the diet. It has been shown that when a fluid contains an excess of proteins, certain bacteria produce toxins; but if the fluid contains an excess of sugars, the same organisms produce acids. Kendall found most bacteria utilize carbohydrate in preference to proteins; that when there is plenty of sugar at hand, they do not attack proteins, consequently toxins are not produced. It changes the character of the bacteria from putrefactive to fermentative. Therefore carbohydrates spare the tissues from destruction, afford heat and energy to the body, prevent acidosis and toxæmia, and assist in a rapid return to normal health and good condition. Taking all these points into consideration, the following example may be considered a typical fever dietary:

Typical Fever Diet.

Amount of Food.	Protein.	Fat.	Carbohydrates.
	Grammes.	Grammes.	Grammes.
Milk, 3 pints	66·0	60·0	81·0
Raw eggs, two	13·5	11·6	—
Oatmeal, 1 ounce	3·6	1·6	17·7
Arrowroot, 1 ounce	·2	—	24·0
Bread, 3 ounces	6·8	1·2	42·6
Butter, 1 ounce	1·0	25·0	—
Sugar, 2½ ounces	—	—	71·0
Barley-water, 20 ounces	3·5	·5	14·5
Beef-tea, 20 ounces	15·0	1·5	1·5
Total	109·6	101·4	252·3

These items would yield about 2,426 calories, and would meet the theoretical expenditure of a case of moderate fever. The addition of another pint of milk would raise the total to 2,836 calories. Such a diet should be aimed at. Some people can easily take it; others cannot consume more than enough to supply 1,800 or 2,000 calories, and some do not digest it very well. There is every degree of variation in the appetite and digestive power. We have previously shown that appetite is no guide to digestive capacity, and that the chief difficulty is to get the food into the digestive tract.

The best sources of protein are milk and eggs. Milk is bland, soothing, and gratifying to the thirsty patient. The flavour is not objectionable. It is easily digested; its waste products do not irritate the excretory organs. It is better to give small doses frequently repeated; 5 ounces every two hours would use up 3 pints of milk a day. If it is vomited, and the curds are large and firm, the milk should be boiled; the curds will then be smaller and less irritating. Boiled milk has the advantage of being sterilized, and the disadvantage of losing the enzymes and antibodies which are present in raw milk. If boiling the milk is not sufficient to check vomiting or pain, it must be diluted with barley-water, lime-water, or soda-water, which prevent the formation of hard curds and relieve irritation. The addition of citrate of soda, 1 or 2 grains to an ounce, prevents the formation of curds. Milk can also be peptonized, made into junket, jelly, or custard. If the patient complains of the mouth being dry, various expedients may be tried for its relief—*e.g.*, sucking a thin slice of lemon, sponging the tongue with boracic lotion, or painting it with glycerine. If the proper quantity of milk cannot be consumed, that which is taken must be fortified by the addition of dried milk powder (*e.g.*, Cow and Gate brand), casein preparations (Plasmon, Protene, Tilia, Sanatogen, etc.). If the flavour of milk is objectionable, it must be disguised by adding some concentrated infusion of tea or coffee, decoction of cocoa-nibs, meat extract, strong soup, boiling the milk with the green tops of celery or an onion.

Eggs come next in importance to milk. Two eggs contain 13·5 grammes of protein, 11·6 grammes of fat, and 163 calories—that is, more nutriment than 1 pint of beef-tea at a quarter the cost. They can be given in milk, soup, tea, cocoa, and other fluids, or in the form of custard.

Beef-tea, soup, broth, and other meat infusions were formerly relied on to a very great extent for feeding feverish patients. This was an error. Clear beef-tea contains little but meat bases, salts, and water. Even when the "grounds" are included, a pint of beef-tea contains only the nutriment of 1 ounce of beef. The salts are out of proportion to the nutriment, and the effect of drinking such a fluid is increased thirst, sometimes a rise of temperature, and the certainty of additional waste nitrogenous matters to be

excreted. A comparison of milk, eggs, and various meat infusions is given in the adjoining table. The figures are by Atwater:

MEAT INFUSIONS COMPARED WITH EGGS AND MILK.

	Water.	Protein.	Fat.	Carbo-hydrates.	Calories.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Lb.
Hen's eggs	73·7	13·4	10·5	1·0	720
Milk	87·0	3·3	4·0	5·0	325
Whey	93·0	1·0	·3	5·0	125
Buttermilk	91·0	3·0	·5	4·8	165
Beef-tea	92·9	4·4	·6	—	115
Bouillon (clear broth) ..	96·6	2·2	·1	·2	50
Chicken soup	93·8	3·6	·1	1·5	100
Julienne soup	95·9	2·7	—	·5	60
Mulligatawny soup	89·3	3·7	·1	5·7	180
Oxtail soup	88·8	4·0	1·3	4·3	210
Tomato soup	90·0	1·8	1·1	5·6	185
Vegetable soup	95·7	2·9	—	·5	65

The superiority of milk and eggs is clearly proved by these analyses. The protein content of meat infusions is very small, and the calorie value of soups depends on the carbohydrates used for thickening them. Soup made from bone and connective tissues—*e.g.*, ox-tail—contain sufficient gelatin to make them stiff when they are cold; 1 per cent. of gelatin will do that. As a protein-sparer gelatin has about the same value as starch. The value of soups can be greatly increased by the addition of eggs, milk, meat powder (meatox, beef meal, somatose, peptonoids), or milk powders. Calves'-foot jelly contains 4·3 per cent. of protein, and 17·4 per cent. of carbohydrate, mostly sugar. Jellies made from fruit contain only 1·5 per cent. of protein, but the carbohydrate may be as much as 40 or 50 per cent.

Carbohydrate foods should be used as much as possible. There is clear evidence that the patient can digest them. They may consist of farinaceous foods, bread-and-milk (the bread should be boiled in water, strained, and beaten with a fork before it is mixed with milk), oatmeal porridge, arrowroot, or milk pudding. There is evidence that root-starch is more quickly digested than cereal starch; hence the recommendation of arrowroot, *tous le mois*, tapioca, sago, and potato starch (British arrowroot) for fever patients is a scientific procedure. Many farinaceous foods have their starch partly transformed into soluble materials. The starch in rice and oatmeal is partly dextrinized during prolonged cooking (four or five hours) in a slow oven. Dextrinization has been largely carried out in the manufacture of many commerical invalid foods. When there is clear evidence that the patient cannot digest ordinary farinaceous materials, some Benger's, Savory and Moore's, or

Mellin's food may be given. Ovaltine, Hygiama, or Hawley's Liebig food may be used for a change. Peptonized gruel or diastased cereal foods are useful.

Sugar is one of the most important protein-sparers. It should be employed to the extent of 2 ounces or more a day. It is a valuable source of energy, cardiac stimulant, and restorative. Ordinary cane-sugar can be given in tea, coffee, cocoa, milk, and all farinaceous foods. If cane-sugar is considered too sweet, some of it may be replaced by lactose, glucose, or extract of malt, which have a similar value. Lactose can be added to milk; glucose to tea, coffee, porridge, or pudding; extract of malt added to milk also changes the flavour and prevents the formation of large curds.

Beverages.—The consumption of a large quantity of fluids is beneficial in all febrile conditions. It quenches thirst, raises arterial tension, removes waste from the tissues, washes away toxins, promotes diuresis and perspiration, increases evaporation from the surface, and tends to lower the temperature. Copious drinking of hot or cold water in fever improves the assimilation of food, and intensifies the metabolism both quantitatively and qualitatively. The patient ought to be encouraged, in reason, to drink plenty of water in its various forms. It may be thought that the amount of fluids in the typical diet given above is sufficient for the needs of the body. Such is not the case. An adult ought to drink 4, 5, or even 6 pints of water in addition to those foods. It may consist of plain water, soda-water, lemon-water, barley or oatmeal water, toast-water, apple-water, black-currant tea, rice-water, orange-water, raspberry vinegar and water, treacle-posset, linseed-tea, sage-tea, imperial drink, whey, tamarind whey, white wine whey, cream of tartar whey, lemon whey, and many other beverages in which water predominates. Ice in small pieces may be allowed when necessary to check nausea or vomiting.

Tea, coffee, and cocoa are useful beverages. But they are something more: they are valuable stimulants and restoratives of a high order—preventatives of fatigue, collapse, and cardiac failure.

Alcohol should be used sparingly, and ought to be reserved for a critical period. In former days alcohol was prescribed freely on the supposition that it lowered the temperature and was oxidized in place of the tissues of the body. It does lower the temperature; ordinary doses reduce it 0·5 to 1·0° F., and larger doses from 5° to 6° F. A certain amount of alcohol is oxidized in the body, each gramme yielding 7·1 calories. It never raises the temperature; it increases the action of the heart, and causes a dilatation of the vessels of the skin, and more heat is lost in this way than the alcohol produces. Alcohol can take the place of fat, to some extent, as a protein-sparer, but it does not take the place of carbohydrate. It has very little effect on the excretion of nitrogen. Some authorities assert that it assists the absorption of fat; others find it decreases the assimilation of both fat and protein. Dujardin-

Beaumetz[1] says: "Some see in alcohol a force-giving medicine which acts in febrile diseases by sustaining and augmenting the strength of the patient; others regard alcohol as an antipyretic, which lowers the temperature and prevents hyperpyrexia; some maintain it hinders organic disintegration, others maintain it acts simply as a food." Dujardin-Beaumetz agrees that alcohol has a beneficial influence by its threefold action as an antipyretic, food, and tonic. As a food, he says, it undergoes more or less complete oxidation at the expense of the oxygen of the blood; it saves the tissues by undergoing oxidation in their stead; the pyrexial phenomena are thus diminished and the temperature lowered. "It also acts on the nerve centres by giving them strength and tonicity, and is therefore a force-giver." On the Continent, wine is generally prescribed, the amount usually being from 5 to 10 ounces of light red wine, such as Burgundy or Bordeaux; strong alcoholic wines and spirits are reserved for severe cases. There is no objection to these wines, nor to port, sherry, or champagne in suitable cases; but in Great Britain an equivalent of brandy or whisky is more commonly prescribed.

The regular use of alcohol in the treatment of febrile disorders is unnecessary. The temperance hospitals have proved that most patients do better without it. Owing, therefore, to the tendency to form a habit, the excuse that the doctor ordered it as a reason for its continued use, and the dire effects of intemperance, it behoves us to be cautious about the use of so powerful, valuable, but pernicious article. The body soon becomes inured to it, and an ordinary dose then fails to stimulate it. When it is given in the early stages of a febrile disorder, the body gets accustomed to it, and is unable to obtain from it the beneficial effects required during a critical period. It should be reserved for cases of exhaustion in which the cardiac muscle, damaged by the high temperature or toxins, fails to do its work adequately. The indications for it are a pulse of 120 or more, a dry, brown tongue, and muttering delirium. If reserved to this period, it will strengthen the failing heart, improve the circulation, clear the brain, enliven the mind, and assist in lowering the temperature. But these effects may be followed by depression spreading from the higher to the lower nerve centres. If the pulse and respiration are quicker after than before it, the thirst greater, the tongue browner, and the mind more obscured, it is doing more harm than good, and should be replaced by musk, ammonia, strychnia, ether, or other drugs. Alcohol is a valuable ally, but may become a dangerous enemy. Much depends on the former habits, the state of the kidneys, and the age of the patient. The following are the cases in which Hutchison considers alcohol to be imperatively necessary: (1) Failing circulation, shown by—(*a*) Persistently rapid pulse (120 or more), weak, irregular, or dicrotic; (*b*) when the first sound of the heart is faint or inaudible. (2) Nervous exhaustion, indicated by the "typhoid state," sleep-

[1] "Du Régime Alimentaire dans les Maladies Fébriles."

lessness, tremors, or delirium. (3) Failure of the digestive power—inability to take food, dry tongue, diarrhœa. (4) Persistent high temperature. (5) Bad general condition—feeble, exhausted, elderly and alcoholic subjects. (6) Specific diseases—malaria, erysipelas, septic poisoning, etc. He recommends malt whisky for most cases, but genuine cognac is better for the "typhoid state" and nervous exhaustion, because it is richer in ethers; old sherry is also rich in ethers, and may be used; dry champagne is better in cases attended by vomiting, and stout is useful for insomnia. The amount recommended is ½ ounce of spirit or 1 ounce of wine every four, three, or two hours, according to necessity. A child should have from 5 to 20 drops of brandy or whisky every three hours, made into a mixture to be taken in 1 to 2 teaspoonful doses. Champagne may be given for vomiting, and port wine or Burgundy in convalescence.

The Diet in Convalescence.—The general rule is not to allow any solid food until after the temperature is normal. But the farinaceous foods, milky puddings, junket, custard, and jelly, may be allowed before the temperature is normal. If they have not been previously allowed, they should now constitute the first addition to the diet. We can then go on to ordinary milk puddings containing eggs—rice, sago, tapioca, vermicelli, semolina, macaroni—cornflour mould and stewed fruit, sponge cake, Madeira cake, and purée or consommé of vegetables. Other foods may now be added in the following order: Eggs (poached or lightly boiled); steamed fish (sole, plaice, whiting, haddock, or cod) and mashed potato; raw-meat sandwiches, raw oysters, boiled fowl, chicken, or stewed rabbit; and finally tender beef or mutton with light vegetables, such as cauliflower, spinach, boiled lettuce, vegetable marrow (squash), a few tender green peas or kidney (string or snap) beans. The ordinary diet may now be taken. The amount of solid food must be increased slowly, otherwise indigestion or gastric catarrh will result. But if the foods be taken in the order given above, the stomach will become gradually used to solid food, and evil consequences may be avoided.

Diseases in which the Fever Diet is Applicable.—The diet given above may be prescribed in a large proportion of acute diseases, such as those in the list on p. 564. It is not claimed that this list is complete. The addition of the words "low," "full," or "generous" indicates a corresponding amount of food. In some diseases a modification of the food is required, and these will be commented on below and in other parts of the book.

There are some diseases in which a modification of the fever diet is necessary. The modes of feeding in a few of the more common ailments is as follows:

Measles.—The general fever diet is applicable to most cases. Young children require milk diet only during the acute febrile stage, with plenty of water or its variants to drink. If the child vomits milk, mix it with lime-water or barley-water. If vomiting is persistent, give albumin-water alone until the vomiting ceases. When

there is no vomiting and the child is obviously being badly nourished, strengthen the milk by adding a raw beaten egg twice a day; or give a teacupful of broth fortified by a beaten raw egg-white, and some farinaceous food may be given. If diarrhœa occurs, avoid the use of broth and beef-tea; give milk and arrowroot, enriched by one raw white of egg to a teacupful. When the rash is gone, the food may consist of milk, milk puddings, custard, jelly, bread and milk, or bread-and-butter. In convalescence the diet detailed under that head should be given in proportion to the age.

Diseases in which the Fever Diet is Applicable.

Abscess of various parts
Anthrax, or splenic fever
Appendicitis (*low*)
Boils; furunculosis
Breast, inflammation of
Bronchitis, acute
Bronchial catarrh
Broncho-pneumonia
Burns and scalds, extensive
Bursitis, acute
Cancrum oris (*generous*)
Carbuncle (*generous*)
Catarrh, acute
Cellulitis (*full*)
Cerebro-spinal fever
Chicken-pox
Cystitis (*low, bland fluids*)
Delirium tremens
Diphtheria (*q.v.*)
Eczema, acute (*low, demulcents*)
Empyema
Endocarditis
Epididymitis
Erysipelas (*full*)
Erythema, acute
Fevers
Gangrene
Gastritis, acute (*q.v.*)
Glossitis, acute
Hepatic abscess
Hepatic congestion, acute
Herpes zoster (*generous*)
Inflammations
Influenza (*generous*)
Intermittent fever
Laryngitis, acute (*low*)
Lichen, acute
Lymphangitis
Malarial fever
Mastoiditis
Measles (*q.v.*)
Meningitis, acute
Meningitis, tubercular
Meningitis, cerebro-spinal
Metritis, acute
Mumps (*low*)
Nephritis (see Acute Bright's disease)
Oöphoritis, acute
Operations, after many kinds
Orchitis, acute (*low*)
Osteo-myelitis
Otitis media
Pancreatitis, acute
Pemphigus, acute (*generous*)
Pericarditis (*q.v.*)
Periproctitis
Peritonitis, acute (*low*)
Perityphlitis (*low*)
Puerperal fever
Pharyngitis
Phlebitis
Plague
Pleurisy
Pneumonia
Poliomyelitis
Prostatitis, acute
Psoriasis, acute
Pyæmia
Pyelitis
Pyonephrosis
Relapsing fever
Rheumatism, acute (*q.v.*)
Rotheln; rubella
Salpingitis
Scarlet fever (*q.v.*)
Septicæmia (*generous*)
Stomatitis
Surgical fever
Synovitis, acute (*low*)
Tetanus
Thrombosis
Tonsillitis (*low*)
Typhoid fever (*q.v.*)
Typhus fever
Typhoses
Urticaria, acute

Scarlet Fever and Diphtheria.—Milk diet only should be given until after the disappearance of the rash. Vomiting is very common

until the rash is well established; but the patient may be given some albumin-water, or equal parts of milk and lime-water, some black-currant tea, or other watery fluid. After the subsidence of the rash, ordinary fever diet should be given until the temperature is normal: bread and milk, well-cooked oatmeal, farinaceous foods, egg-custard, junket, baked apple, etc., may now be given if the patient can swallow them. If the fever is prolonged, milk, raw egg, beef-tea, gelatin-water, etc., should predominate in the diet. In septic cases there may be persistent vomiting or diarrhœa. Vomiting may be checked by the use of albumin-water, lime-water and milk, Valentine's meat-juice, barley-water and cream, but it may need the use of champagne or brandy and soda-water. Occasionally it necessitates resort to rectal feeding. In bad cases the stomach may be washed out twice a day with a warm solution of sod. bicarb. and sod. chloride. But a concurrent diarrhœa may render rectal feeding useless. In such a case the vomiting and diarrhœa may be simultaneously relieved by an aperient and rectal irrigation. Diarrhœa occurring alone may be checked by arrowroot or cornflour and milk, Brand's essence of beef, albulactin, glaxo, glidine, or Plasmon. But in a serious case the colon should be washed out, a saline fluid injected into the rectum or areolar tissues, and brandy or champagne given freely. When the diarrhœa is over, the milk should be peptonized and some Benger's or Mellin's food given for a few days. Sugar may be given freely, especially glucose or maltose. Ordinary cane-sugar is excellent to prevent cardiac failure. Jelly may be given, but sago or tapioca-jelly, with sugar and cream, are better than meat jelly.

Much difficulty in swallowing may necessitate nasal feeding. Adults sometimes swallow thick foods easier than fluids—*e.g.*, bread soaked in milk, boiled egg, minced beef, chicken or rabbit, baked custard, junket, blanc-mange or jelly. But a slight paralysis of the palate may cause young children to regurgitate food through the nose. Children should not be allowed to feed themselves when this occurs. During the meal they should be placed in the Casselbury position—*i.e.*, lying on a nurse's knees with the head a little lower than the body. In this position the swallowing is easier, and the child can be fed with a spoon. In very severe cases nasal feeding must be resorted to, and generally it gives better results than rectal feeding. The nasal tube should be insinuated carefully through the nostril. Milk, Plasmon, raw egg and milk, arrowroot, Mellin's food, peptonized foods, meat juice or extract, may be given. If the patient is up, he should be sent back to bed as soon as paralysis occurs.

Cardiac failure may arise from toxæmia or degenerative changes in the myocardium. Ordinary stimulants are of little use in such a condition, but brandy or champagne may be tried. Ordinary cane-sugar, musk, ether, ammonia, and strychnine are useful.

Albuminuria and Convalescence.—It is considered by some authorities that the fever diet should be kept up until all danger

from nephritis is past. But in the third week of the illness an adult may usually be allowed some white fish, mashed potato, boiled vegetables, and stewed fruit. Boiled rabbit or fowl may be allowed a few days later, and from that time the ordinary diet may be gradually resumed.

It is not uncommon for albumin to occur in the urine during the course of any febrile disorder; it consists of serum-albumin and globulin. Albumoses may also occur when very rapid destruction of the tissues is taking place. This is due to the general febrile condition. But in scarlatina and diphtheria the albuminuria is often due to some change in the kidneys, which may be due quite as much to toxins as to the high temperature. The diet has no influence in causing such albuminuria. In 10,983 cases treated with a liberal diet, Craiger found nephritis occurred in 11·9 per cent.; and in 4,486 cases treated with a restricted diet, Ker found nephritis and albuminuria in 11·2 per cent. Craiger concluded that there was no evidence of nephritis being caused by the use of **liberal diet** in the acute stage of scarlet fever. He follows the general rules for feeding fever patients, and prescribes milk, raw eggs, soup, or beef-tea in the febrile stage. As soon as the temperature is normal he prescribes custard, junket, milk puddings, soft-boiled eggs, bread-and-butter, if they can be swallowed; and two or three days later he adds to the list light fish, minced meat, chicken cream, and mashed potato.

A restricted diet is prescribed by Jaccoud, Moizard, and other authorities in Europe and America, who insist upon nothing except milk being allowed until one week after the temperature is normal. Some people keep up the milk diet until four to six weeks after the disappearance of the rash. Such restriction is seldom necessary. Jaccoud prescribes, a week after the temperature is normal, 2 to 4 pints of milk, eggs, white meat, and vegetables; fish is not allowed so early. If the eggs and milk were partly transformed into custard and junket, the diet would not differ materially from Craiger's. Forcheimer prescribes a liberal fever diet, but from the end of the second week to the end of the fourth week he restricts the patient to milk. Carbohydrates are then added, and if no bad result occurs, meat next, and then ordinary diet is resumed. Although diet alone does not cause albuminuria, it is reasonable to spare the kidneys at a critical period. Nephritis occurs between the sixteenth and twenty-sixth days from the beginning of sore throat. During this period they appear to be depressed; and whether we regard nephritis as originating from bacteria or pyrexia, it is proper to spare them by avoiding irritating foods, such as beef-tea, soup, meat extracts, etc., during that period. Scarlatinal nephritis is most common in young children, and it is an easy matter to restrict them to milk, farinaceous foods, puddings, potatoes, vegetables, bread-and-butter. It is less common in adults, and greater latitude may be allowed in feeding.

The treatment of nephritis from scarlatina and diphtheria does

not differ from that detailed under Acute Nephritis (p. 408). Milk is by far the best diet, but it may be diluted with whey or barley-water, or mixed with arrowroot or oatmeal gruel. Imperial drink and similar fluids may be given to quench the thirst. If the albuminuria persists longer than three weeks, the diet should be improved by the addition of eggs, tender meat, and digestible vegetables. If there is a persistent dropsy, a chloride-free diet should be prescribed. It should not consist entirely of milk. The patient may have eggs, meat, salt-free bread, vegetables, saltless butter, cream, jam, boiled rice with golden syrup, sago, tapioca, custard, Iceland moss jelly, and other jellies.

Typhoid or Enteric Fever, and the Typhoses.

Typhoid fever presents itself in many forms, and has frequently been confounded with other diseases. The characteristic temperature curve, roseolar rash, enlargement of the spleen, and diarrhœa with peasoup stools, form the typhoid syndrome. Many of the cases originally diagnosed as typhoid may be found on closer inspection to belong to the group of diseases which have not inaptly been termed the *typhoses*. This group includes—(1) Paratyphoid typhosis of Achard and Bensaude, in which the bacteria are intermediate between Eberth's *Bacillus typhosis* and *Bacillus coli;* (2) Landouzy's typho-bacillosis or septicæmia, due to Koch's *Bacillus tuberculosis;* (3) Fournier's syphilitic typhosis, a typhoid form of syphilitic roseola; and (4) meningococcal typhosis, or typhoid cases of cerebro-spinal meningitis, with diarrhœa, rose-coloured spots, etc. All these affections require practically the same dietetic treatment, and they will be considered together.

The Dietetics of Typhoid Fever and the Typhoses.—It has long been the custom to treat typhoid fever with fluid foods only. In 1894 Curnow laid down the dietetic law that no typhoid patient should be allowed any solid food until the temperature has been normal for at least ten days. The reason given for this rule is the belief that the earlier administration of solid foods would cause a relapse, and probably perforation of the intestines. But it has not been a universal experience to find relapses, hæmorrhage, perforation, or other dire effects following the use of the ordinary fever diet, such as that given above (pp. 458-563). The subject has been much debated, and the experience of many physicians has led them to adopt some form of dietary very different from the fluid foods so strongly recommended by Curnow and others. Niemeyer, after stating the rule of fluid dietary, in 1874 wrote thus: "I have no hesitation in saying that the aggravation of the fever by eggs, meat, and milk has not been proved." In 1882 Hoesslin gave eggs, meat, soup, bread, milk, and porridge. In 1887 Khadgi gave a similar diet; and both concluded that the course of the fever was not greatly influenced by meat, eggs, and bread, when properly prepared. But the results obtained by other men have led to the adoption by

them of such different dietaries that they need to be classified. They are as follows: (1) Water diet, *traitement à la vide*, or the empty bowel method; (2) scanty fare—milk, 20 to 30 ounces a day, and water; (3) whey; (4) moderate feeding—ordinary fever diet; (5) liberal feeding; (6) generous feeding. A few remarks on each will be given.

Milk and Farinaceous Foods—*Moderate Feeding*.—The following is the dietary I have used for more than thirty years, with satisfaction to myself and advantage to my patients; I have every confidence in it, and strongly recommend it: The daily food of an adult should consist of—Milk, 4 to 5 pints; sugar, 2 ounces; raw eggs, 2 or 3; beef-tea, mutton or chicken broth, 1 pint; farinaceous foods, *q.s.*; custard and jelly, *ad libitum*. The milk should be given in doses of 5 to 7 ounces every two hours. Its digestion must be carefully watched. If milk curds appear in the stools, much valuable nutriment will be lost, and meteorism may be caused by the passage of such curds along the intestinal canal. This must be prevented by the use of barley-water, lime-water, citrate of soda, extract of malt, or peptonizing powders, to prevent the formation of masses of curd. Junket, made by commercial junket-powder, tablets, or essences, is a soft jelly-like substance in which the milk is curdled before it is consumed. The curdling of milk is also prevented by the use of farinaceous foods, which insure a subdivision of the casein. In an average case of typhoid fever, *some of the milk* can be thickened with arrowroot, cornflour (or starch), fine rice-flour, Mellin's, Savory and Moore's, and other foods. Benger's food is very useful. The sugars from these foods will be completely absorbed; 85 to 90 per cent. of the starch will be absorbed. If less than this is taken up, it will have served a useful purpose in preventing the coagulation of casein in large and indigestible curds. The experiments in digestion and metabolism previously referred to (pp. 556, 576) show that a considerable proportion of protein, fat, and carbohydrate will be digested. Even when there is much diarrhœa, the absorption of food is not greatly diminished, providing the milk is not in large curds. Moreover, the diarrhœa can be more or less controlled by the combination of white of eggs, arrowroot, cornflour, cinnamon, or nutmeg with milk. Brandy will also assist in checking the diarrhœa. If the diarrhœa persists, beef-tea and yolk of eggs should be left out of the dietary. Mutton broth and chicken broth do not always provoke diarrhœa, even when beef-tea does so. When constipation occurs, cornflour and arrowroot must be avoided; beef-tea may now be useful, and some of the milk may be given with boiled bread, well-cooked fine oatmeal, glucose, treacle, demerara sugar, honey, apple sauce, apricot sauce, and fruit-juices (*e.g.*, orange, lemon, grape, strawberry juice, etc.).

As a general rule the patient may be allowed as much water and its variants as he desires; in fact, he should be encouraged to drink. Copious drinking increases the assimilation of proteins, improves

the metabolism of nitrogen, increases arterial tension, and excretion by the skin, lungs, and kidneys. The existence of diarrhœa does not preclude copious drinking. The water may be taken hot or cold, and flavoured with tea, lemon-juice, fruit-juice, or other agents previously mentioned in the fever diet. Alcohol may be required (see Fever Diet), but it is not necessary for every case, nor is it always beneficial. Diakanov found the temporary use of alcohol lowered the assimilation of protein by typhoid patients, the effect being greatest in those not accustomed to alcohol. It also lessened appetite and increased the amount of fæces, but it improved the general condition.

The importance of carbohydrates in every case of fever has been commented on. When patients are badly fed, their tissues are rapidly destroyed, and acidosis occurs. Under these circumstances the use of carbohydrates is an essential part of the treatment. Moreover, it is believed that carbohydrates prevent the toxæmia, which is a marked feature of the disease, by preventing the formation of toxins in the cellular tissues. At the same time they are protein-sparers. During his observations, Gairdner fed his patients with a mixture containing 7 ounces of milk, 1 ounce of cream, and 1 ounce of lactose, every three hours. The results were as follows: Absence of the typical typhoid facies; toxæmia less marked; restlessness and delirium less than usual; no marked emaciation; appetite was good, food well digested, stools formed; and the return to normal health was rapid.

Foods to be avoided in Typhoid Fever.—Oatmeal, brown bread, bread crusts, toast, vegetables, and raw fruit.

Convalescence is said to begin when the morning temperature sinks to the normal level. This is the usual period to begin making additions to the diet. The appetite now returns, the patient begins to be hungry, and there are evidences that the body is ready for a larger dietary. But every addition must be experimental, although it is essential that sufficient be given to satisfy hunger. The food should be well cooked, and no irritating particles ought to pass the lips. Certain foods are absorbed almost entirely in the upper bowel, and these may usually be given without fear—*e.g.*, rice, sago, and tapioca. Therefore a well-cooked milk pudding is usually safe to give. About the same time we can allow some boiled bread and milk, sponge cake, Madeira cake (without fruit), finger biscuits. Some scraped meat may be given as a sandwich two or three times a day.

If the patient is going on well, the temperature undisturbed by the former additions to the diet, and the period of lysis nearly over, as shown by the evening temperature approximating to the normal line, we may next allow a few teaspoonfuls of steamed fish (sole, plaice, whiting, weak-fish, or fresh haddock), the same amount of potato purée, and stale bread (free from crust). After four or five days, eggs (poached or boiled) may be allowed for breakfast; and breast of chicken or stewed rabbit, potato, vegetable marrow, and

pudding for dinner. A few days later some underdone beef or mutton may be given. Ordinary diet should be attained in about two weeks from the establishment of normal temperature.

Relapses.—If the morning temperature rise above normal, it is essential that the patient should be put back on the original diet until the cause of the pyrexia has been discovered. It may be due to constipation, phlebitis, superficial abscesses, otitis media, or a genuine recrudescence of typhoid from fresh infection. During convalescence of an ordinary case of typhoid fever, the temperature often sinks a degree or two below normal. This need not surprise us. The fierce oxidation in the tissues is over; the body is exhausted; nearly all the glycogen and fat is burnt up, and muscular tissue alone is being oxidized, as it must be while the supply of food is deficient. The evening temperature may at the same time be a degree or two above normal. This is often due to starvation, and a few satisfying meals will frequently bring it down. The morning temperature is the most important guide, and a rise of one degree above normal should cause a searching inquiry. A relapse is a rise of temperature and return of the symptoms of typhoid fever. It may be due to an enlarged spleen. In such a case the relapse is not due to overfeeding; it is quite as likely to occur in a patient fed with slops and other meagre fare as in one who is well fed. It may also occur from constipation. There is no doubt that a relapse sometimes recurs from injudicious feeding, and especially after eating toasted bread. But these are not instances of genuine relapses; the temperature subsides as soon as the cause is removed.

Water Diet (Starvation Diet, the Empty Bowel Treatment, or "Traitement à la Vide").—This mode of treatment was commonly used on the Continent in the Middle Ages, and is still used to some extent, but is unpopular in England. The dietary consists of plenty of plain water, barley-water, oatmeal-water, and water-soup. A generation ago German and French physicians considered the administration of milk, eggs, broth, meat, and other nutritious articles decidedly injurious, and "water-soup" was regarded by them as the proper fever diet. The mortality from typhoid fever was much higher than in England, and this was attributed by Englishmen to the Continental treatment by starvation. Niemeyer admitted the truth of this assertion. I have already quoted his statement, but it is worth repeating: "I have no hesitation in saying that the aggravation of fever by giving the patient milk, eggs, and meat has not been proved by actual observation. . . . In every fever the consumption of the constituents of the body is greatly increased, and no sort of exercise will use up the body as rapidly as fever does. . . . Most fatal cases of fever are due to insufficient material being furnished for the replacement of that used up. Even in the most favourable cases during convalescence we see greatly debilitated patients, who have lost 15 to 20 pounds in weight, recover slowly. These facts urge us to give milk, eggs,

and even meat, etc., until it shall be proven that such diet increases the fever." *Traitement à la vide* includes the consumption of a very large amount of water. By this means the waste of the tissues is washed out of the body, the nitrogenous materials being more efficiently oxidized, the proportion of N of urea to N of purins being nearer the normal level—that is to say, nitrogen metabolism is improved both quantitatively and qualitatively. The copious drinking of water also increases the excretion by the skin and lungs, and raises the arterial tension. Copious water-drinking along with other food is now recommended for all fevers. As a general rule, 3, 4, or 5 pints a day may be allowed, in addition to milk. But the forced consumption of 8 to 10 pints a day by typhoid patients is another matter. In 1890 the effects of water were investigated by Diakonov, Matzkevich, Grudiev and Puritz, and by Débove in 1894, and more recently by Cushing and Clarke. The occurrence of diarrhœa does not preclude the consumption of a large amount of water. The urine is increased, and toxins are removed with the débris of the tissues. The beneficial effects most obvious are the diminution of restlessness, headache, delirium, and other consequences of the toxæmia. But it has no influence on the temperature, pulse, or rate of respiration. Meteorism is rather frequent. Another point of importance in connection with copious drinking is the removal of mineral salts from the body. Febrile urine always contains a larger proportion of potassium than normal urine, but a diminution of sodium salts. Röhmann found that chlorides are not excreted in the fæces or urine during fever, and the chlorides in the blood are diminished; therefore they must be retained in the tissues.

The observations recorded on p. 572 were made by Gramatchikov on cases of typhoid fever. The food in every case consisted of bread and milk, and in some cases, even during the fever, meat was added. During the fever there was an increased excretion of potassium salts. The metabolism of sodium was also increased, but in a lesser degree; the metabolism of calcium and magnesium was very little changed; and the metabolism of nitrogen, sulphuric, and phosphoric acid was increased.

Necessity for Chlorides.—In typhoid patients the chlorides of the urine are diminished. This may be due to a smaller consumption or diminished excretion of salt by the kidneys, increased excretion of chlorides by the bowels, or retention of chlorides in the tissues. Chlorides of sodium, potassium, and calcium are necessary for proper metabolism, to preserve the integrity of the blood-plasma, for the functioning of leucocytes, and for proper cardiac action. We do not know the meaning of chloride retention; it may be of a protective character. It does not occur in every case, and appears to depend on the total amount of liquids consumed, and chiefly on the consumption of milk: 4 pints of milk contain from 45 to 50 grains of NaCl, of which a normal person retains about 20 grains and a typhoid person 35 grains. When the patient consumes 5 or 6 pints of water in addition to the milk, the chlorides are not retained. The excessive water drinking leads to depletion of the system of chlorides. A typhoid patient drinking 9 or 10 pints of fluid a day may retain a smaller proportion of chlorides than a normal person taking

METABOLISM OF MINERALS IN TYPHOID FEVER.—GRAMMES DAILY.

Condition.	KCl. Food.	KCl. Urine.	KCl. Fæces.	KCl. + or −	NaCl. Food.	NaCl. Urine.	NaCl. Fæces.	NaCl. + or −	CaO. Food.	CaO. Urine.	CaO. Fæces.	CaO. + or −
A. Fever	3·3	3·0	1·9	− 1·6	3·7	1·8	2·4	− ·5	3·1	·1	2·7	+ ·3
No fever	4·1	2·9	3·8	− 2·6	9·1	7·7	·7	+ ·7	2·2	·3	1·2	+ ·6
B. Fever	3·0	2·7	1·9	− 1·6	2·4	1·2	1·5	− ·3	3·6	·5	2·9	+ ·2
No fever	1·8	1·7	·2	− ·1	8·0	8·5	·8	− 1·3	·4	·2	·2	+ ·0
C. Fever	4·9	3·5	2·0	− ·6	3·8	2·4	1·7	− ·5	4·1	·4	3·5	− ·1
No fever	4·0	2·7	1·4	+ ·1	11·3	10·1	1·9	− ·7	2·2	·4	1·7	+ ·7
D. Fever	3·1	3·3	·7	− ·9	2·6	1·3	·7	− ·6	3·1	·4	2·7	+ ·0
No fever	2·0	1·4	·5	+ ·1	7·8	5·3	1·4	+ 1·1	·5	·2	·2	+ ·1
E. Fever	1·7	2·6	·7	− 1·6	1·4	1·3	1·0	− ·9	2·0	·2	1·6	+ ·2

Condition.	MgO. Food.	MgO. Urine.	MgO. Fæces.	MgO. + or −	SO_3. Food.	SO_3. Urine.	SO_3. Fæces.	SO_3. + or −	P_2O_5. Food.	P_2O_5. Urine.	P_2O_5. Fæces.	P_2O_5. + or −
A. Fever	·7	·2	·4	+ ·1	4·8	4·1	1·3	− ·6	5·3	2·5	3·8	− 1·0
No fever	·8	·3	·3	+ ·2	4·9	2·8	·5	+ 1·6	5·6	2·8	1·4	+ 1·4
B. Fever	·6	·3	·3	+ ·0	4·1	4·8	1·0	+ 1·7	4·2	3·1	2·8	− 1·7
No fever	·5	·2	·2	+ ·1	1·4	1·4	·1	− ·1	3·1	·2	·9	+ 2·0
C. Fever	·7	·1	·6	+ ·0	6·7	4·3	2·1	+ ·3	5·1	2·7	3·1	− ·7
No fever	·9	·3	·5	+ ·1	4·8	2·3	·9	+ 1·6	6·1	2·5	2·2	+ 1·4
D. Fever	·6	·3	·4	− ·1	4·5	4·0	1·3	− ·8	3·8	3·3	1·9	− 1·2
No fever	·6	·2	·4	+ ·0	1·7	1·4	·1	+ ·3	3·2	·2	1·2	− 1·8
E. Fever	·4	·1	·3	+ ·0	2·8	3·3	·5	− 1·0	2·4	2·5	1·3	− 1·4

ordinary food. Hoffmann and Sollmann found that, given a superabundance of water, any addition of chlorides to the food was followed by a prompt increase of chlorides of the urine. A dilute saline solution is absorbed more readily than plain water, and it is believed the depletion of the system of its chlorides is prevented by alkaline carbonates given in the water. It is therefore recommended that each pint of water should contain 25 grains of sodium chloride, 12 grains of potassium bicarbonate, and a dessertspoonful of lemon juice or fruit syrup, and some sugar to flavour it.

Whey Diet.—Williams, believing that the exhausting diarrhœa of typhoid was due to irritation of the mucous membrane by food, endeavoured to carry out the treatment by allowing the patients plenty of water to drink, and in some cases as little as ½ pint of milk a day. Ewart recommended whey as a food which leaves a very small residue. Ker also says: "If milk is badly tolerated, an admirable substitute is to be found in whey." The amount of whey recommended by Ewart is 2½ to 4 pints in twenty-four hours, some sugar and 15 grains of salt being added to each pint. When meteorism (if it occurs) has subsided, he orders white of eggs and cream. If the fæces are satisfactory, and the food agrees, he adds fruit juices, jellies, honey, and vegetable soup. The food value of this diet must be examined. Droop Richmond states the average composition of whey is as follows: Lactose 4·45, protein 1·24, ash 0·52, per cent. The fat rarely exceeds 0·5 per cent., and may be less. Therefore 5 litres (8¾ pints) contain carbohydrate 222·5, protein 62, fat 17·5, grammes; and energy, 1,324 calories. This quantity, which is double the amount prescribed by Ewart, is a very small provision for a person whose metabolism is increased 20 per cent. by fever. The addition of 2 ounces of sugar, two raw eggs, 7 ounces of cream, and 8 ounces of calves'-foot jelly, would raise the proteins to 90 grammes, and the energy to 2,147 calories; but it would still be a poor diet for fever, although it should not be despised under certain conditions, such as inability of the patient to take milk, prolonged vomiting, etc.

Buttermilk contains more proteins, the composition being as follows: Water 90·83, proteins 3·37, fat 0·31, sugar 4·50, ash 0·81, per cent. It might be used with the same success as whey. Stoos found the acidity of buttermilk a disadvantage in cases of vomiting, but other practitioners have not raised the same objection to it.

Milk Diet (Scanty Fare).—Milk has long been recognized as the staple diet for typhoid fever. The present writer quite agrees with this, but does not agree that it should be the sole diet. Among recent writers Ker advocates the employment of a scanty milk diet during the acute stage of typhoid, and also in relapses and prolonged fever. He orders the patient to be fed every two hours from 4 a.m. to midnight with 3 ounces of milk, making a total of 33 ounces of milk in twenty-four hours. In addition, he recommends 7 ounces of hot beef-tea or chicken broth to be given three times a day. The total value of this diet is 49 grammes of protein, and at most 800 calories. He does not allow any farinaceous food

until a few days after the temperature returns to normal. The milk is to be always well diluted with water, soda-water, etc. He says it is seldom advantageous to increase the milk to 4 ounces every two hours, and that is his maximum allowance. The dangers from such a scanty diet are acidosis and the consequences thereof.

Milk and Farinaceous Food (Moderate Fare).—It must be admitted that milk alone may give rise to a considerable amount of trouble. Ker says: "The value of milk is beyond all question, and is still recognized by most authorities as the most suitable diet in enteric fever. There are, however, few foods capable of doing more harm." If milk is the sole diet, and more is ingested than the alimentary canal can deal with, large masses of curd are left undigested, and irritate the ileum and colon. The curdling of milk is natural, but it can be prevented by the use of farinaceous foods, such as Benger's, Mellin's, baked flour, fine oatmeal, boiled bread rubbed through a sieve, barley-water, lime-water, etc. By following out the dietary of the author, previously detailed, the patient can take a larger quantity of milk at each meal, and the total provision of food will be moderately increased. With respect to diarrhœa, it may be stated its occurrence has little effect on the digestion and assimilation of properly prepared food. Moreover, some carbohydrates serve the triple purpose of loosening the curd, checking diarrhœa, and preventing acidosis.

Milk-free Diet.—Patients can be carried through typhoid fever without any milk at all. It was claimed by Sibert[1] that the course of the disease is thereby shortened. He dieted his patients in the following manner: On the first day he gave nothing but water and a dose of calomel. On the following day soup made of rice, barley, and oatmeal; this was strained, and mixed with yolk of eggs and extract of meat. Later on he gave meat broth, and allowed the patient to eat zwiebach. Hydrochloric acid was given between meals; and the bowels were irrigated daily. He claimed that the patients became convalescent much sooner than with milk diet. The temperature was lowered, complications prevented, nervous symptoms fewer, and mortality diminished. Strong also treated cases with milk-free diet consisting of broth, crackers, zwiebach, rice, and gelatin. He considered the results justify its use. He said there was less prostration, no diarrhœa or tympanites, the tongue became clean and moist. He sometimes gave pepsin and hydrochloric acid after meals, but intestinal irrigations were not regularly used. Kemp endorsed the use of milk-free diet, and considered milk was one of the principal causes of danger in typhoid, because the motor power as well as the digestive function of the stomach was defective in the acute stage of typhoid. He employed rectal irrigations regularly.

"Liberal" and "Abundant" Dietaries.—Hippocrates used to feed fever patients with flour soup. A little later it became the custom to give an ordinary diet. In the Middle Ages the patient

[1] *Medical Record*, June 20, 1908.

was starved or fed on water soup. But in the nineteenth century Graves in Ireland and Trousseau in France objected to the treatment by starvation, and were the first to employ diet of a nourishing character. But the treatment by "low diet" was used a long time, and it was not until after Hoesslin's experiment in digestion by typhoid patients that any notable improvement occurred. Of late years many physicians have given a far more abundant dietary. Klemperer,[1] for instance, says the increased consumption of the albuminoid tissues, and the great amount of "cast-off cell protoplasm," demands an increased supply of material; about 2,500 to 2,800 calories are required to satisfy the organism and for repairs in the cell protoplasm. Bauer also believed that an abundance of protein is necessary; that some is used in the construction of new cells, and it allays the craving of the organism for albumin.

Theoretically, a liberal and varied diet ought to be of great value to obviate the waste of tissues arising from the enormous oxidation which is going on. The body wastes considerably on a scanty diet, and the suggestion is forced upon us that the heart and intestines must be proportionately affected; indeed, the intestines are often extremely thin in fatal cases examined post mortem. Many authorities have prescribed a liberal dietary without experiencing those dire results which are predicted by men in the opposite camp. And some of those who prescribe very scanty fare during the acute stage advocate a speedy return to more abundant diet as soon as the morning temperature becomes normal. Thus Ker[2] is "convinced that the use of solid food early in convalescence does much to shorten the duration of the case . . . the liberal supply of food at this period helps to promote the healing process in the ulcerated intestines, and to repair the waste caused by fever . . . and probably prevents such sequelæ as periostitis, abscesses, and otitis media." If a more liberal dietary is justifiable the moment the morning temperature drops to normal, may it not be equally justifiable at an earlier period—say, the beginning of lysis, when the appetite returns? As a matter of fact, such dietaries have long been in use. In 1886 Kadgi of St. Petersburg gave the following diets: (1) Milk 1,110, bread 155, meat 21, broth 92, grammes; (2) milk 1,345, bread 701, grammes; (3) milk 714, bread 154, meat 65, broth 51, grammes; (4) milk 703, bread 86, meat 42, broth 149, grammes; (5) milk 790, bread 103, meat 74, and broth 187, grammes. He found 83·9 per cent. of the protein was absorbed.

In 1890 Matzkevich gave a mixed diet of bread, cutlets, and milk during the febrile stage. The protein of meat and bread was digested, as well as that of milk. Grudiev gave as much as 735 grammes of bread with milk and plenty of water. Gramatchikov gave as much as 180 and 192 grammes of meat.

In the same year Puritz made observations on abundant diet

[1] *Berl. Klin. Woch.*, January 30, 1899.
[2] Sutherland's "System of Dietetics," p. 324.

in the acute stage of typhoid; he fed patients with bread, meat, milk, and wine, including 180 grammes of protein, 60 to 90 grammes of fat, and 300 grammes of carbohydrate—enough for a man doing a hard day's work. He compared the patients with others to whom he gave a light diet, containing 40 grammes of protein, 10 to 20 grammes of fat, and 100 to 150 grammes of carbohydrate; and he arrived at the conclusion that patients with typhoid fever can eat with impunity and digest considerable quantities of protein and carbohydrate when they take plenty of water or similar fluids.

Finally, the observations of Hoesslin[1] made in 1882 on the digestibility of various foods by typhoid patients may again be quoted. These investigations were made in the hospital at the time when Rubner was conducting his investigations on the digestibility of foods by healthy men. The following items are from the series of diets given by Hoesslin to typhoid patients: (1) Soup, 1,583 grammes; (2) 29 egg yolks, and 2,500 grammes of soup; (3) 1,994 grammes of porridge, made of coarse oatmeal; (4) 1,556 grammes extract of meat; (5) 396 grammes of ham; (6) 100 grammes of rice; (7) 24 egg yolks; (8) 3,000 grammes of milk; (9) 977 grammes of white of egg; (10) 3,778 grammes of porridge from coarse wheat-flour, and 300 grammes of wine; (11) 1,750 grammes of milk; (12) 471 grammes of ham; (13) 1,500 grammes of milk; (14) 494 grammes of ham; (15) 1,400 grammes extract of meat, 500 grammes of soup, and 400 grammes of wine. In each case the food was carefully prepared, and analyzed to ascertain its exact composition. The fæces and urine were collected and analyzed. Many of the patients had more or less diarrhœa. *When diarrhœa was severe, the dry matter of the fæces was not materially increased.* When the fever was moderate, the digestion and assimilation of protein, fat, and carbohydrate was not much different from that in healthy persons. There is, therefore, little doubt that food can be digested. But it is reasonable to recommend care in the preparation of the food.

In 1897 A. G. Barrs[2] of Leeds made a plea for the prescription of a less restricted dietary in typhoid fever. He said: "No one can fail to be impressed with the extreme emaciation, feebleness, and prolonged disablement which that disorder entails." He prescribed bread-and-butter, poached eggs, minced meat, bacon, rice pudding, custard, stewed fruit, sponge cake, porridge and milk, etc., to patients whose temperature was 100° to 101° F. in the morning, and 101° to 102° F. in the evening. He said: "I do not give solid food to patients suffering from enteric when they cannot take it; but if a patient can take solid food, I give it him. That solid food, when the patient's appetite and digestion permit him to take it, is deleterious in the presence of pyrexia is incorrect. I am unable to find any reliable observations which support the notion. . . . When a patient likes a thing and has appetite for it, it is a sure indication it will agree, be digested, absorbed, assimilated, and

1 Virchow's *Archiv*, lxxxix. 106-109.
2 *Brit. Med. Jour.*, 1897, i. 126.

tend to the well-being and not to the undoing of the patient. It is my rule, therefore, to give a typhoid patient such wholesome solid or liquid food as he likes, wishes for, and enjoys. I do not give solid food to all cases. To give a patient with a dry, shrivelled tongue, teeth covered with sordes, semi-comatose, and indifferent to all around him, especially to food, meat and other solids would be as cruel as to withhold it from one who is genuinely hungry. . . . It is difficult for me to conceive any method of treatment more calculated to delay healing of the ulcers and favour perforation than the prolonged system of starvation which fluid feeding adds to the devastating effects of pyrexia."

These observations are not accepted by the generality of the profession without question. There is strong opposition in some quarters to the employment of solid food until ten days after the temperature is normal. West[1] is convinced that too early and incautious use of solid food is attended by considerable risk of relapse. "I have seen relapse follow so often that I cannot question the fact; and the relapses have occurred not only when solid food has been given prematurely, but when the change of diet has been from one kind of liquid to another. I have seen it follow orange-juice or grape-juice without pips. The risk is a relapse—a recrudescence of the disease—with all its consequences. . . . Opinions differ widely as to what is the best diet. To my mind it matters little, so long as the diet is liquid, sufficient in quantity, agrees with the patient, and is not changed."

But other physicians have given solid food without fear, and their results, as far as ultimate recovery is concerned, have been equally good, and they claim to have had fewer cases of hæmorrhage and perforation. Bushuyer gave the following dietary during the acute stage; it is an extreme example of liberal feeding with solid food, and is one I should not recommend:

Early Breakfast.—Tea, roll and butter.

Breakfast.—Given in three parts: 8 a.m., porridge made of boiled oatmeal, barley, or wheatmeal, 13 fluid ounces; 9 o'clock, two eggs, boiled soft or hard as the patient likes; 10 o'clock, a cutlet, roll, and tumblerful of milk.

Lunch, 12.30.—A breakfast-cupful of clear soup or beef tea, and an equal quantity of jelly.

Tea, 3 *p.m.*—A roll and butter, tea with cream and sugar.

Dinner.—6 p.m. a cupful of chicken broth or beef-tea, breast of chicken, potato purée, milk pudding, or milk to drink; 8 p.m., a roll and butter, milk to drink.

During the Night.—Milk-tea or coffee made with milk, a cupful given twice or thrice.

Stimulants.—Wine (1 to 3 ounces) at 10 or 11 a.m., and a tablespoonful of brandy mixture every two hours.

Bushuyer made every effort to stimulate the appetite, and considered that when the patient could be interested in his food, the general condition of his organism rapidly improved. There is no doubt that the characteristic apathy of typhoid is one of the worst

[1] *Brit. Med. Jour.*, 1897, i. 260.

features of the condition. Out of 398 cases treated by Bushuyer with the above dietary relapses were not common, only four had hæmorrhage, only one had a perforation, and the mortality was only 8·2 per cent.

The dietary of Shattuck,[1] of the Massachusetts General Hospital, is rather more moderate in character, and the majority of the articles included in it may be recommended with safety; indeed, many of them have been prescribed by me for thirty years. Shattuck's dietary is derived from the following list, and the amount of protein, fat, and carbohydrate recommended is the same as for a healthy individual.

Milk, hot or cold, with or without salt, lime-water, soda-water, Apollinaris, Vichy, or other alkaline waters; peptogenic powder or peptonized milk; milk with whole egg, white of egg, tea, coffee, or cocoa.

Soups, made of beef, mutton, veal, chicken, oysters, peas, beans, squash, or tomato; they should be strained and thickened with rice-flour, wheat-flour, barley, arrowroot, eggs and cream, Horlick's malted milk, or Mellin's food.

Cream, cream and barley-water; whey, buttermilk, koumiss, Matzoon.

Beef-juice, bovinine, carnipeptone, somatose.

Gruel, made of cornmeal or oatmeal and strained, and farinaceous foods.

Eggs, soft boiled, raw, or in egg-nog; ice-cream.

Meat, scraped or finely minced; the soft part of raw oysters.

Puddings, soft puddings without currants or raisins; macaroni, blancmange, apple-sauce, wine jelly.

Soft crackers with tea, soup, or egg-nog; soft toast without crust.

Drink: plain water, barley-water, lemon-water, albumin-water, tea, coffee, and cocoa.

Strause, in urging the use of a similar dietary, says the absorption of meat and soft foods is only 5 to 10 per cent. less than in a normal person. When patients are fed on a liberal dietary, the death-rate is lower, perforation and hæmorrhage less frequent than in those fed on fluid and less satisfying diet, and, with the exception of a slight increase in the percentage of relapses, the results are all in favour of liberal feeding; and the amount of food should be not less than that allowed for a healthy person. Kinnicutt also recommends the dietary, and gave the following figures: In 4,654 cases of typhoid fed on a liquid diet, relapses occurred in 10·88 per cent., hæmorrhage in 8·83 per cent., perforation in 2·40 per cent., and death in 10·55 per cent. In 733 cases fed liberally relapses occurred in 11·38 per cent., hæmorrhage in only 4·77 per cent., perforation only in 1·36 per cent., and death only in 9·47 per cent. of cases.

Acute Rheumatism (Rheumatic Fever).

The occurrence of an excess of acids in the perspiration during acute rheumatism suggests that these are the cause of the disease. This is the humoral theory. The bacterial theory is more popular. Moreover, various bacilli, micrococci, and diplococci found in the joints produce on cultivation formic, acetic, lactic, butyric, and propionic acids.

[1] *Amer. Jour. Med. Sci.*, May, 1909.

The food should consist entirely of milk and watery fluids so long as the acute symptoms last. Each pint of milk should have $\frac{1}{2}$ teaspoonful of bicarbonate of soda or potash, and $\frac{1}{4}$ teaspoonful of common salt, added to it. Four pints a day will be required to meet the physiological requirements of the body while at rest in bed. This should be the standard for a man, and a woman or child should have a proportionate amount. But even this liberal allowance of liquid will not suffice to meet the demands of the organism. The fever and drenching perspiration cause great thirst. It is therefore proper to dilute the milk with one-third of barley-water, oatmeal-water, soda-water, Perrier, Apollinaris, Salutaris, or other gaseous water. By these means the tendency of milk to form hard curds will be obviated. In a very bad case 2 grains of citrate of soda may be added, instead of the bicarbonate, to each ounce of milk. Milk often coats the tongue and causes a dry mouth. These are usual effects of the milk diet. It may be relieved by other drinks, taken extra—*e.g.*, imperial drink, lemon-water, apple-water, plain water, whey, tamarind whey, buttermilk. One ounce of lemon-juice contains 30 to 45 grains of citric acid, which is anti-rheumatic. It is hardly necessary to add that broth, soup, meat extract, jelly, and other articles containing meat bases and purins should be prohibited.

When the acute stage is passing off, some oatmeal gruel, barley meal, farinaceous food, custard, junket, jelly, or milk pudding may be given. Von Noorden and Mohr consider oatmeal the best food for all acid auto-intoxications; Winter asserts that *all* cereals are equally valuable. Malted, dextrinized, and predigested cereal foods should not be used, but only freshly prepared cereals; neither should much sugar be allowed with them.

The next addition, after cereals, should be stale bread-and-butter, and potatoes baked in their skins, so that the potassium salts are retained. About the same time we may add some fresh fruit, especially grapes, strawberries, raspberries, blackberries, logan-berries, and oranges; they should be eaten without sugar. Sugar-containing roots and tubers, such as beets, yams, sweet potatoes, etc., should be forbidden.

The first animal food should consist of eggs in the form of custard, soup with eggs, and poached or boiled eggs. After a day or two, if these agree, some boiled light fish may be given; and in a few days chicken panada, breast of chicken; and finally tender mutton or underdone beef. Care must be taken not to increase the animal food very rapidly. When chicken or meat is allowed, it may be accompanied by potatoes, spinach, cauliflower, kidney beans, a spoonful or two of green peas, vegetable marrow, boiled celery, or lettuce.

Meat soups should not be allowed for a week or two after meat. But vegetable soups may be allowed about the same time as eggs and fish. Onion, mint, leek, celery, lettuce, endive, tarragon, savory, cabbage, and other vegetables should be boiled together

for several hours until the whole is reduced to a purée; it should then be mixed with some boiled milk and a raw egg, to give protein and fat, and seasoned with salt and pepper.

After convalescence the patient must be careful to avoid any cause of gastro-intestinal irritation or catarrh and hepatic hyperæmia, which are believed to delay complete restoration from acute and subacute rheumatism. Tea, coffee, and especially alcohol, should be avoided for a long time if they cause the least indigestion. All general hygienic measures capable of promoting the establishment of good general health and freedom from metabolic disorders should be adopted.

CHAPTER XXIII

THE VITAMINES AND THE DEFICIENCY DISEASES

The chief constituents of foods are proteins, fats, carbohydrates, and salts. But clinical and experimental observations show that foods contain something more than albumin, globulin, glutelin, casein, stearin, palmitin, olein, sugar, starch, and dextrin. Very many foods contain an exceedingly small but important amount of accessory substances, which have recently been shown to be essential for the growth, development, and well-being of the organism. When these substances are excluded from the food, the body suffers, and sooner or later becomes subject to various diseases. What these substances are and the rôle they play in metabolism is the subject of considerable discussion and investigation. Light has been thrown on them by recent researches. Various substances have been isolated whose presence in foods influences favourably the well-being of the organism, and whose absence tends to the opposite condition. Among these are the substances called **vitamines.** It has long been known that animals grow quicker, larger, and become heavier when fed with some kinds of foods than others. It has also been known a long time that when people are fed with a monotonous diet—*e.g.*, rice, maize, white bread, pickled meat, and canned foods—the body suffers and certain diseases are developed. These diseases are due to the absence of vitamines, and they are cured by the administration of substances which contain them. There is, for instance, a growth-producing vitamine in fresh milk, eggs, meat, yeast, meat extract, yeast extract, in growing grain (*e.g.*, malt), and in all grains which have not been deprived of the pericarp (wheat, oats, barley, red rice, maize), and in the substances which have been removed from them (*e.g.*, wheat bran, rice bran, maize bran, the germ of wheat and other cereals, and malt culms), and in Hongo or Katjang idjo beans, and all rapidly growing vegetables.

But there are other vitamines than those which promote growth in eggs, meat, fish, brain, cereals, legumes, fresh vegetables, and yeast. This is shown by ill-effects resulting from the absence of fresh foods, and the beneficial effects which follow their use. In fact, most fresh animal and vegetable juices contain vitamines. They are chemical organic substances which are easily destroyed by exposure to heat, and soon perish if they are kept. Their exact chemical nature has not been worked out in every case, but they are known to be derivatives of nuclein and nucleic acids. Their

importance is obvious. Professor Leonard Hill says: "Foods contain a number of vitamines, and white bread does not contain those vitamines. In the milling process the outer layers of the wheat berry are removed and the vitamines taken away. That does not matter to people who get meat and eggs and vegetables. But it does matter to people whose principal diet is bread. If one saw children having tea and white bread with a smear of jelly, called jam, there would be no vitamines in that. If wholemeal bread or black bread were substituted, they would have vitamines." This is not all; poor people use a good deal of condensed milk and canned food. Sterilizing milk and canning foods deprive them to a greater or less extent of their vitamines. The rôle of the vitamines in metabolism is not yet properly settled, but it is probable that they are "activators," or hormones, whose work is in the digestion and application of the foodstuffs.[1]

VITAMINES AND GROWTH.—The work of Osborne, Mendel, Hopkins,[2] McCollum and Davis,[3] shows that there is in some foods a specific growth-producing vitamine.

Vitamines in Milk.—F. Gowland Hopkins conducted feeding experiments illustrating the necessity for "accessory" substances in normal dietaries, and read a paper before the Royal Society of Medicine in October, 1913, in which he demonstrated the necessity of vitamines for normal growth. Groups of young rats were fed on a basal diet of casein, fat, carbohydrates, and salts. They were compared with other rats fed with the same diet plus a minute ration of fresh milk. The amount of food consumed was practically the same throughout. The former rats soon ceased to grow; the latter grew normally. The small addition of milk imparted to the diet some substance which was essential. What the actual substances are in milk which so markedly, although in a secondary way, affected the growth is not yet known. The milk vitamines are destroyed by boiling it. One laboratory fact has been pointed out[4] which might well be followed up. Milk which is preserved by hydrogen peroxide readily causes scurvy. It is deprived of its antiscorbutic properties; in other words, hydrogen peroxide has a specific effect on the vitamines.

The vitamines of mother's milk are necessary for the growth and development of the child. If the mother herself suffers from a deficiency disease—*e.g.*, beri-beri—the child will suffer, because her milk is deficient in these indispensable substances. Andrews[5] says

[1] Casimir Funk, "The Probable Rôle of Vitamines in the Digestion and Application of Food," Proc., Physiol. Soc., December 13, 1913; and "Die Vitamine," *Ihre Bedeutung für die Physiologie und Pathologie mit besonderer Berücksichtigung der Avitaminosen*, 1914.

[2] Hopkins, "Feeding Experiments illustrating the Importance of Accessory Factors in Normal Dietary," *Jour. Physiol.*, 1912, 425-460; Hopkins and Neville, "The Influence of Diet on Growth," *Biochemical Journal*, 1913, 97.

[3] "The Necessity for Certain Lipins in Diet during Growth," *Biochemical Journal*, 1913, 167.

[4] *Edinburgh Medical Journal*, January, 1914, 2.

[5] *Jour. Trop. Med.*, 1913, 370.

half the mortality in Manila consists of infants under one year of age; and half the infants who die show some sign of beri-beri. As three-fourths of the infants are breast-fed, there is an undeniable relationship between the milk and the absence of growth, development, and sound health. Manila infants fed by a healthy mother or with fresh cow's milk do not develop beri-beri, but develop normally, which shows the milk of healthy women contains vitamines, that of unhealthy women does not. The disease is also cured by feeding the infants with fresh cow's milk or other substances which are proved to contain vitamines.

Experiments have recently been made in feeding animals with isolated proteins to discover their efficiency or otherwise as a food material. Osborne and Mendel[1] fed rats with isolated proteins, fat, sugar, starch, and salts. But the food was deficient; they *failed to grow.* A preparation of protein-free milk was subsequently added to the diet; this contained the milk-sugar, salts, and unknown components of milk. Rats which were malnourished and failed to grow on the former diet resumed their growth and became " re-alimented " as soon as the protein-free milk was added, and were carried through two generations. Thus adequate growth was noted when the sole protein consisted of casein, lactalbumin, egg-albumin, edestin, glutenin, and glycinin. Rats which had developed marked symptoms of decline on isolated proteins were revived in a way little short of marvellous when protein-free milk was given as part of the food; thereby it was shown that there are in milk traces of essential compounds which promote growth and are essential for that purpose. Further observations were made by Osborne, Mendel, Ferry and Wakeman,[2] when they concluded that the " vitamines " of milk are to be found in the butter-fat fraction, but their chemical nature is unknown. Osborne and Mendel[3] had previously shown by feeding rats on *fat-free* foods that it was not fat itself which causes growth; the rats continued to grow and thrive on a diet completely free from fat, and almost free from lipoids. The diet certainly did not contain any significant quantity of phosphatides and cerebrosides (see Lipoids, p. 613).

Similar observations have been made on chickens. Casimir Funk fed chickens on casein, fat, carbohydrate, and salts. The chickens ceased to grow and developed polyneuritis, which is the beri-beri of birds. He concluded this was due to the absence of vitamines. Other chickens were fed with ordinary food, and they grew normally. He then fed some chickens with polished white rice; they ceased to grow, developed beri-beri, and died quickly. He also fed chickens on unpolished rice; these birds also ceased to grow, but did not develop beri-beri. Other birds were fed with unpolished rice and yeast, and they grew slowly. The conclusion drawn from the observation is that normal food contains a growth vitamine, but it is not the same as the beri-beri vitamine.

[1] *Science*, 1911, 722-730. [2] *Jour. Biol. Chem.*, 1913, 423-437.
[3] *Ibid.*, 1912, 82-89.

These observations are very suggestive. It is not uncommon to see children of stunted growth, even when there is no evidence of hypothyroidism. This is probably due to the absence of the specific growth vitamine from their food.

Vitamines in Wheat and Flour.—Experiments have shown that as regards digestibility and availability, bread made from ordinary household or bread flour and from patent flour have a superiority over brown and so-called "standard bread." Dr. Hamill[1] examined the evidence published with regard to the nutritive value of various kinds of flour. Entire wheat flour, both stone ground and so-called "standard" or 80 per cent. flour, contain less available protein than patent or standard patent flour. But there is a difference in entire wheat flour and 80 per cent. flour, owing to the presence of small branny particles and the germ of wheat, which contain additional constituents and have a value of their own in nutrition. Among these constituents are phosphorus-containing organic compounds and other substances which may prove to be of importance in nutrition. This consideration applies to wholemeal flour and germ flour, and the bread made from them.

It is an undeniable fact, proved by many experiments, that a vast difference exists in the effects on animals of entire wheatmeal and ordinary white flour. This difference is due neither to protein nor phosphates. During the controversy on standard bread, the Millers' Association obtained analyses of four kinds of flour made from the same lot of wheat, and the results were as follows:

	Protein.	Phosphates.
	Per Cent.	Per Cent.
1. High-grade flour .. .. 2. Town Household, or ordinary bread flour	12·36	0·327
3. Wholemeal flour .. .. 4. Standard or 80 per cent. flour	12·17	0·321

The difference as regards protein and phosphates was actually in favour of white flour and bread. But it has been shown that the value of different parts of the grain for nutritive purposes cannot be determined merely by an estimation of the protein, fat, and carbohydrate. Biological experiments are necessary for this purpose. Milk drawn from a healthy animal contains all the groups necessary for the growth of the young mammal. The wheat grain or berry contains all the groups necessary for the growth of the young plant, and there is nothing in the grain which is not useful for the growth of the sprout. Hill and Flack[2] showed distinctly that rats fed on entire wheatmeal, standard flour (80 per cent.), and Hovis flour

[1] Foods Reports, Nos. 11 and 12, Local Government Board, 1911.
[2] *Brit. Med. Jour.*, 1911, i. 1311; and ii., September 16.

grew normally, and produced young; but rats fed on white flour did not grow normally and did not produce young, or, if they did, the young did not thrive. It was shown by Tibbles that the nutrition of rats fed on white flour was likely to suffer from the absence of cellulose, the latter element being a *sine qua non* of proper nutrition in animals possessing a long intestinal canal, like rodents. Nevertheless, sufficient observations have been made to prove the value of those substances in whole wheatmeal which are deficient in white flour and bread. Pigeons were fed by Edie and Simpson[1] with white bread and wholemeal, or standard bread. Those fed with standard bread maintained their weight, paired, and laid eggs; those fed with white bread immediately began to lose weight, manifested illness, and developed polyneuritis. Some of the latter died; others were cured, and recovered their weight and fitness when fed on whole grain or whole grain and yeast. It was concluded that the parts of wheat removed in milling include substances which are necessary for growth, maintenance of nutrition, and even life itself. These substances are important both for the growing and adult animal. The milling of wheat, therefore, is a question of national importance. This, however, is by no means the first time the matter has been discussed. The question of standardizing bread was discussed in great detail and debated in the House of Commons in 1768;[2] in fact, "the bread problem has exercised the minds of rulers of the people from the earliest period of English history." J. H., writing in 1773, says: "Whatever mixtures of grain or qualities of bread might be the food of some of our ancestors, the common standard of bread, from Alfred's time down to the eighth of Queen Anne, was three-fourths of the wheat, which represented all the flour." The writer says we went on very well for 800 years, but in Queen Anne's time it was thought proper that three sorts of bread should be assized, "so that instead of flour for bread and bran that remained, assize bread became a mystery, and we no longer knew what we were eating." The miller divided the flour, but in the attempt to prepare one for white, another for wheaten, and the third for household bread, the inferior kind became disagreeable to the taste of those accustomed to finer bread. The inferior bread contained the pollard and fine bran, which few people chose to eat if they could obtain the finer kind, and so the people, rejecting what they called "brown" bread, took to the wheaten, which they called "white" bread, and from that day to the present the greatest attention has been paid to the production of the finest and whitest bread. But to obtain the finest flour and whitest bread it has become necessary to remove all the bran and the germ. By so doing, however, the miller and baker have impoverished the flour and bread of some of the most important constituents—viz., the vitamines, enzymes, activators, amino-acids and lipoids, which only exist in the germ and subpericarpal layers of the bran of wheat. The removal of these

[1] *Brit. Med. Jour.*, 1911, i. 1151. [2] *Ibid.*, 1914, i. 772.

substances does not matter very much in the case of well-to-do families, where fresh milk, animal foods, and vegetables containing vitamines are constantly a part of the daily diet. But it matters greatly to children of the poor, whose chief diet is white bread. Hill and Flack, who fed rats on various flours, proved that the germ and bran of wheat are necessary to make them grow; Edie and Simpson showed pigeons also require them. Growing plants require all the grain contains, and the children of the poor ought to be given what growing animals and sprouting corn require. Centuries ago bread corn had to be ground in the quern, an ancient means of grinding still used by native races, and it was never free from the germ and bran. Races of people are to-day fed with oatmeal, ryemeal, and barley-meal, which are never so finely milled as white flour. Barley bread was formerly a staple food in England. The superior results obtained from feeding animals on meal which is not deprived of the germ and bran led to investigations into the differences in composition. Observations have shown that proteins are not equally efficient for maintaining growth, and some of them are deficient in particular amino-acids. Zein or maize protein is deficient in tryptophane; it does not cause growth, and is insufficient to maintain life. Mice fed on zein plus tryptophane lived longer than on zein alone. It appears that the superior value of standard and wholemeal bread is due in part to the fact that tryptophane and other important amino-acids are split off earlier in digestion than from white flour. To test this point Hopkins digested various flours with pancreatic extract, and estimated the amount of tryptophane liberated. The digestion of the germ itself gave the least evidence of tryptophane; but the digestion of standard or wholemeal flour gave evidence that a greater amount of tryptophane was split off than from germ alone or fine white flour.

Vitamines in Rice.—When young birds are fed on red or unpolished rice they grow normally and maintain their health; but if they are fed on polished or white rice, their growth ceases, they speedily develop polyneuritis (beri-beri), and die. The insufficiency of white rice as a food has been studied by many men, and reports are numerous. Out of the many, I will mention that Kajiura, in connection with Rosenheim,[1] worked out the proteins of rice, which does not appear to have been done previously. They found that rice completely lacks a protein soluble in alcohol, such as gliadin in wheat and hordein in barley. They thought this might account for the insufficiency of white rice as a food. They fed groups of birds on rice plus gluten, rice plus hordein, and rice plus calcium carbonate and phosphate. In no case, however, did they succeed in appreciably delaying the death of the birds. Control birds fed on barley grew normally and maintained their health. These observations showed that lack of gliadin or hordein was not sufficient to account for the different effects of barley and polished rice.

Polished or white rice comprises those rices which in the process

[1] Proc. Physiol. Soc., 1908, liv.; and *Jour. Physiol.*, 1908, ii. 317.

of milling have been deprived of their husk or shell, pericarp, subpericarpal layers, and the germ. After *padi* or red rice is hulled, and the husks removed by winnowing, the grain is passed into a polishing apparatus. There it is deprived of the pericarp, yellowish subpericarpal layers, and the germ. The end of each grain of polished rice shows a depression which, in the entire grain, contained the minute yellowish embryo. The removal of these structures leaves a grain composed of cells packed with starch. The substances removed during polishing are driven by centrifugal force through the meshes of a wire cloth. They form the rice-polishings, rice-bran, or meal. It necessarily contains the embryo, amino-acids, vitamines, and other substances contained in the outer layers of rice. Fraser and Stanton[1] proved that the deeper layers of the pericarp (the *silver skin* of Dutch authors) removed in polishing rice contain a substance or substances essential to the organism. Fresh polished rice is as bad as stale rice. Many observations have since been made on it. The essential substance is contained in an alcoholic extract of rice polishings, for birds and human beings suffering from beri-beri due to eating white rice have been cured by adding alcoholic extract of rice polishings to the diet. Among other investigators, Edie, Simpson, Moore, Evans, and Webster,[2] working in Liverpool, confirmed the discovery that rice-bran and its alcoholic extracts contain substances of a protective and curative nature if such extracts are concentrated under a fan and not on a water-bath, thereby showing that the protective substances are destroyed by moderate heat. Casimir Funk, working at the Lister Institute, has done a vast amount of work in connection with the protective substances, and to him they owe the name of "vitamines," because they are nitrogenous substances, probably amines, and essential to life.

Vitamines in Maize.—Indian corn or maize is used to an enormous extent as a food for animals and men in various parts of the world. As a feeding material, however, it is considered somewhat deficient. It is used at many butter and cheese factories as a means of utilizing their waste products, buttermilk and whey, which make good the deficiencies. Maize contains proteins which maintain weight and promote growth and development, for the growth of animals fed on maize progresses normally, and it appears the effective protein is maize-glutelin. Osborne and Mendel[3] found when fed on zein, the chief protein of maize, animals soon ceased to grow; but maize-glutelin provided a sufficiency, and animals fed with it developed normally. Casimir Funk[4] considers the pericarp or outer layers of maize contain vitamines. The mode of preparation of maize-meal varies in different countries, and the manifestations of pellagra, believed to be due to the consumption of maize as the principal food, vary from mild to severe. Modern milling

[1] *Jour. Trop. Med. and Hyg.*, 1911, 333.
[2] *Philippine Jour. Med.*, 1912, 42.
[3] *Science*, 1913, 189. [4] *Jour. Physiol.*, 1913, 389-392.

deprives the maize of much salts, protein, fat, and lipoids. Maize has always been used largely as a human food in countries where it is grown, especially in America, Africa, and Italy. It formed a large part of the food of soldiers during the American Civil War, but there seems little evidence that pellagra occurred among them. This was probably due to the method of grinding it. The ancient method of grinding maize between stones is still prevalent in parts of America, and flour so prepared is preferred in the Southern States; it makes the most palatable bread. Such meal, having only the coarse bran removed, has nearly the same composition as the entire kernel. But it requires to be used quite fresh, on account of its hygroscopic character and the high proportion of fat; it is very liable to become mouldy and rancid. These faults are remedied by the modern method of milling, which is as follows: "The corn is passed through a machine, which cracks the grain and loosens the germ; the germ and hull are then removed by bolting cloths and currents of air. The corn is afterwards ground between corrugated iron rollers and bolted."[1] The product is a granular meal consisting of 65 to 70 per cent. of the entire grain, but it has lost 75 per cent. of the fat, the germ, and the important substances of the pericarp.

Vitamines in Meat.—Fresh meat contains substances, besides protein and fat, which are of importance to the animal organism; dried meat is deficient in those substances. It is believed that the vitamines are in the plasma or muscle juice, and that they form the preventative and curative agents in raw meat and raw-meat juice. Richet and Héricourt found the efficacy of raw-meat juice in curing tuberculosis lies in the muscle plasma. That it is not due to proteins is shown by the fact that muscle plasma contains very little nitrogen —only 0·4 per cent., equal to 25 grammes of protein in a kilo of muscle juice. Whatever the organic principle may be, it is destroyed by heat, for cooked meat and cooked meat-juice have none of the therapeutical effects of raw-meat juice. The destruction by heat depends on the temperature. There are some substances in cooked fresh meat, besides protein and fat, which make for the well-being of the organism, providing the heat is not excessive or the cooking prolonged. Various observations have shown that the vitamines are destroyed by heat of 120° C., and the interior of a joint of meat weighing 5 or 6 pounds never exceeds 60° C. during ordinary cooking. Fresh meat contains vitamines which protect the body from scurvy and beri-beri. Grijns,[2] who was the first worker to adopt the deficiency theory of beri-beri, says the disease breaks out when a substance necessary for the metabolism of the nervous system is lacking in the food. He found similar protective substances in meat, and showed that they are destroyed when heated to 120° C.

But it is considered that vitamines exist in properly made extracts

[1] Tibbles, "Foods: their Origin, Composition, and Manufacture," p. 481.
[2] *Gen. Tydsch. voor Nederl. Indie*, xli., 1901.

of meat. Observations have shown that the addition of certain commercial extracts of meat to the diet promote growth. Extract of meat is prepared by extracting minced meat with an equal weight of water, and afterwards raising the temperature slowly to 70° C., at which degree it is maintained for several hours; the liquid so obtained is then concentrated at a low temperature. Extract of meat contains 10 or 12 per cent. of creatin and creatinin, besides leucin, tyrosin, xanthin, hypoxanthin, and adenin. Kutscher[1] more recently isolated from meat various other bodies—*e.g.*, ignotine, novaine, carnitine, oblitine, vitiatine, etc. It is a common experience that sailors fed a long time on dried or pickled meat, dried potatoes, rice, biscuit, and bread, develop scurvy and beri-beri, thus proving the absence from dried foods of some substances essential to health; and they recover when fed with fresh meat, fresh vegetables, yeast, Katjang idjo beans, and testicular extract, which contain vitamines.

With regard to tinned foods, it has been shown that they can only be sterilized by exposure to a temperature of 120° C. (248° F.) for not less than sixty minutes. This alone would certainly destroy the vitamines. A failure to sterilize might also lead to destruction of vitamines. Perfectly fresh meat is acid; meat pickled with much potassium nitrate is alkaline. Now, the *Bacillus putrificus coli* (*B. cadaveris sporogenes*, Klein) is present in the colon of animals, and contaminates all meat. Its spores are only killed by exposure to a temperature of 112° C. for fifteen minutes, 115° C. for ten minutes, or 117° C. for five minutes; failure to reach these temperatures in the interior of the tin means failure to sterilize. The bacilli are now given an opportunity to develop and decompose proteins and other organic compounds, and the sulphur from decomposed proteins forms sulphide of iron, which blackens the tin, while the generated gas may cause the tin to be "blown."

Vitamines in Yeast.—Beri-beri was prevented and cured by Schaumann when he used yeast. He endeavoured to find out what is the protective agent. He tried nuclein and nucleic acids derived from yeast, but did not get satisfactory results. Eijkmann, however, found the protective substance is something soluble in 80 per cent. alcohol, and Funk considers it is a vitamine, probably a nitrogenous substance.

Yeast contains several vitamines. The rapidity of growth and multiplication of cells when yeast is placed in sugary solutions show that it contains a growth vitamine, and its ability to cure beri-beri shows that it contains the beri-beri vitamine. Yeast is rich in nucleo-proteins, which yield on decomposition phosphoric acid, purin bases, pyrrimidine bases, and carbohydrates of the pentose type. The purins are chiefly adenin, guanin, hypoxanthin, and xanthin. Edie, Simpson, Moore, Evans, and Webster[2] made an alcoholic yeast of extract in large quantities, and obtained a sub-

[1] *Zeit. Nah. Genusmittel*, x. 528.
[2] *Phil. Jour. Med. Sci.*, 1912, 423.

stance which was decidedly effective in preventing and curing beri-beri. This substance on purification yields feathery crystals, of which they calculated the formula. Funk[1] also investigated a vitamine, which he obtained from yeast; he found it was separable into several substances possessing different melting-points and solubilities, but he advised the whole fraction to be used in the treatment of beri-beri.

Vitamines in Vegetables.—Peasants living on potatoes, cabbage, and a little bacon are practically exempt from scurvy, beri-beri, and other diseases afflicting various people consuming a diet richer in the primary elements of the food. This is surprising until it is considered that such a diet might be richer in vitamines than that containing a greater abundance of protein, fat, and carbohydrates. It has been shown that fresh potatoes, cabbage, carrots, onions, various leaves—*e.g.*, dandelion—are particularly rich in vitamines, and so are some fruits, especially limes and apples. The beri-beri vitamine of rice is destroyed at a temperature of 120° C. Cabbage loses its protective power when heated to 110° C., and cabbage-juice when it is heated to 60° or 70° C., and it is destroyed by keeping it several months. Effront found that the non-protein nitrogenous substances in potatoes stimulate enzyme action and cell growth. Potatoes are largely used by bakers to promote the growth of yeast. It has also been shown that drying potatoes destroys the vitamine which exists in those kept in the ordinary way. Holst and Frölich found most of the above vegetables contain a substance which protects the human body from scurvy, and Funk has called this substance the "scurvy vitamine." With regard to potatoes, it is known that they contain a proportion of non-protein nitrogen, which includes substances possessing the power of *activation*.

VITAMINES AND DISEASE.—The dietetic cachexias are—(1) Those following a deficiency of fresh animal and vegetable foods, such as scurvy, rickets, and scurvy-rickets; (2) those produced by the want of a definite principle in the pericarp of grains—*e.g.*, beri-beri, polyneuritis gallinarum.

Scurvy.—This disease is common among explorers, in armies, and among sailors, when they are confined to a monotonous diet, and especially when it consists of dried or tinned meat, dried vegetables, and bread. And it is certain there is nothing like fresh meat, onions, and vegetables for curing it. There is probably a common basis of dietetic error in the causation of scurvy, rickets, scurvy-rickets (Barlow's disease), ship beri-beri, and polyneuritis gallinarum. The latter was discovered by Eijkmann,[2] a Dutch physician then resident in Java. He noticed that fowls develop peripheral neuritis when fed on white rice, pearl barley, sago, or tapioca. He subsequently found the disease occurred when fowls were fed on meat and wholemeal bread which had been cooked in an autoclave for two hours at 150° C. Red rice, whole barley, oats, and rye,

[1] *Brit. Med. Jour.*, 1913, i. 814.
[2] *Virchow's Archiv*, cxlviii., 1897, 523.

when boiled at 100° C. in the ordinary way, did not cause the disease.

It is generally admitted that scurvy is due to the food, and I have elsewhere argued that it is due to the absence of *freshness* in the food. While vegetables and meat are fresh, their salts are partly dissociated or ionized, and such ions are of importance for metabolic purposes. When foods are not fresh, when they have been dried, pressed, tinned, processed, autoclaved, the salts are no longer in the ionic condition, and are partly inert. But it has been shown that the substance which protects the body from scurvy is a vitamine. The arguments for this are interesting. Holst and Frölich[1] found that animals fed for several weeks with rye, barley, decorticated barley, oats, or flour of wheat, barley, oats, or rice, develop symptoms like human scurvy, and die in a few weeks. The addition of fresh foods, especially vegetables, was sufficient to protect the animals from scurvy. Holst and Frölich used fresh potatoes, apples, carrots, dandelion leaves, and also lime-juice. But it was found these foods could only protect the body when they were used quite fresh; their protecting power was lost when dried, processed, or autoclaved. This explains the reason why foods kept a long time in barracks and on board a ship cause scurvy. A guinea-pig fed with fresh potatoes alone will live for months, but ultimately die without any sign of scurvy; a guinea-pig fed on potatoes which have been dried and subsequently boiled develops the characteristic signs of scurvy, and dies in a few weeks. No difference occurs whether the potatoes are dried in air or *in vacuo*. The same things occur when cabbage or carrots are used.

Infantile scurvy occurs in children fed on boiled, sterilized, or condensed milk. The earliest description of this disease was by Barlow,[2] but its connection with condensed milk was discovered by Neumann,[3] and confirmed by Heubner, Meyer, Brachi, Carr, and Bartenstein. An examination of the bones and other tissues led to the conclusion that infantile scurvy is identical with scurvy, and both are due to a deficiency of substances in the food whose nature is not yet fully settled. There is evidence that boiling milk destroys something essential for normal metabolism, and its destruction leads to scurvy in infants and small animals fed with such milk. Guinea-pigs fed with boiled milk by Bartenstein developed a disease which he considered identical with infantile scurvy. Frölich observed that guinea-pigs fed with milk heated to 100° C. for ten minutes and for thirty minutes, or to 112° C. for one hour, developed a high degree of fragility of the bones, which is a characteristic of scurvy. Frölich also experimented with milk heated to 70° C. (the temperature necessary for pasteurization), and found it did not cause scurvy in guinea-pigs; on the other hand, it

[1] Trans. Soc. Trop. Med. and Hyg., 1911, v.; *Jour. of Hyg.*, 1907, vii. 619-634.

[2] Medico-Chirurg. Trans., 1883, 187.

[3] *Deutsch. Med. Woch.*, 1902, 628-647.

prevented scurvy in guinea-pigs fed on oats, but when milk was heated for ten minutes at 98° C. (just below boiling-point), it entirely lost that protective power. There is sufficient evidence to prove that fresh milk contains small quantities of substances which protect the organism from scurvy, and are otherwise necessary to the maintenance of health, and that such substances are destroyed during boiling and condensing the milk.

The exact nature and composition of the scurvy vitamine is still unknown. Investigators are still at work on the subject. But it is well known that fresh meat, fresh milk, fresh potatoes, onions, carrots, cabbage, dandelion and other leaves, apples and some other fruits, and especially lime-juice, are valuable curatives, as well as preventatives of scurvy. Schaumann considers ship beri-beri, which is allied to scurvy, is due to an acute deficiency of phosphorus in the organism—possibly nucleins—and tropical beri-beri is due to a chronic deficiency in a smaller degree; that there is a strong probability that scurvy is due to a similar deficiency of organic phosphorus; that scurvy-rickets, osteomalacia, pellagra, and other diseases of malnutrition owe their origin to a similar cause. There is, however, a vast amount of evidence to show that scurvy and its allies are prevented and cured by foods which contain vitamines. But the vitamines in such foods are destroyed by heat of a temperature which varies with the kind of food. Thus it was shown cabbage loses its protective power when heated to 110° C., and the vitamine in cabbage-juice is destroyed at 60° or 70° C. Lime-juice contains 1 part of vitamine in 100,000, but it is not destroyed even by boiling it for an hour. The vitamine in milk is also fairly stable, but it is certainly destroyed at 120° C., or lower when it is heated a long time. The scurvy vitamine could not be detected in a commercial sample of dried milk, and it is probable that the amount of vitamine in cow's milk depends entirely on the quantity of vitamines in the cow's food and other points of importance.

Beri-Beri.—This is defined by Vedder[1] as "an acute or chronic disease characterized by changes in the nervous system, and particularly by peripheral neuritis, resulting from faulty metabolism, usually seen only in persons who eat rice as a staple article of diet, and directly caused by the deficiency of vitamines in the food." Several writers prior to 1900 suggested that beri-beri was distinctly connected with the consumption of polished white rice. This connection was proved by Ellis, and also by Braddon,[2] who found that when cured rice was used, beri-beri did not occur; but when uncured polished or white rice was used, beri-beri did occur. Rice is cured by soaking it forty-eight hours in water; it is then put into boilers and steamed until the outer coats burst, usually ten or twelve minutes. It is then dried in the sun, put through a mill, and

1 "Beri-Beri," by Captain E. B. Vedder, Medical Corps, U.S. Army. Bale, Sons and Danielsson, 1913.
2 "The Cause and Prevention of Beri-Beri," 1907.

polished in the usual way. To test this theory Gilmore Ellis[1] carried out experiments at Singapore Lunatic Asylum, 1900 to 1908. Before that period 40 to 59 per cent. of the deaths per annum were due to beri-beri, but in consequence of these experiments the disease now seldom occurs there. In 1904 Ellis fed all patients with "cured" rice for nine months, and no case occurred; in October he began to use "uncured" or ordinary polished white rice, and in December fifteen cases of beri-beri occurred. In 1905 he changed from cured to uncured rice several times, and the results confirmed the belief that beri-beri is due to eating uncured rice. In 1907-08 all patients were put on cured and uncured rice alternately for a period of four months alternately. It was thereby shown that beri-beri only occurred when uncured rice was used, and during the periods when cured rice was used the patients tended to get well.

There is a vast amount of evidence to connect beri-beri with the consumption of polished white rice. This is not all from Oriental countries; nor is white rice the only cause of the disease. Lovelace[2] records the prevalence of beri-beri among labourers constructing a railway in Brazil. There was a case mortality of 15·6 per cent. The diet was abundant and varied, but consisted chiefly of dry biscuit, dried meat, cured fish, tinned meat, tinned fish, beans, and macaroni. Some of the subjects of beri-beri had not eaten a grain of rice for many months. A year later the number of cases was trebled. In 1910 fresh meat, potatoes, and onions were included in the diet. The number of cases now fell off; but in spite of improved diet there were some cases, and the cases were more numerous in some camps than others. These facts show that a deficiency of vitamines was the cause of the disease, for it is now known that vitamines are destroyed by drying and canning the food.

Braddon,[3] who was the first to demonstrate conclusively that beri-beri in the East is produced by the consumption of rice from which the albuminous layers of the pericarp have been removed, records a great reduction in the number of cases of beri-beri in the hospitals, prisons, and asylums of the Malay States by the adoption of a proper diet and exclusion of polished white rice. According to Braddon, there are 150,000 Tamils in British Malaya who never eat uncured rice, and never suffer from beri-beri. In the same area are a great number of Chinese who prefer uncured rice, because it has a pearly appearance and makes a better show; and 97·5 per cent. of the cases of beri-beri are Chinese coolies. There is plenty of evidence to show that not only human beings, but fowls, pigeons, ducks, mice, rats, guinea-pigs, apes, and other animals, readily become ill and finally die of beri-beri when fed exclusively on polished white rice. Wellman, Bass, and Eustis,[4] working in

[1] *Brit. Med. Jour.*, 1909, ii. 935.
[2] *Jour. Amer. Med. Assoc.*, 1912, ii. 2134.
[3] *Jour. Trop. Med. and Hyg.*, 1913, 282.
[4] *Jour. Amer. Soc. Trop. Dis.*, 1912, No. 20

New Orleans, found polished Louisiana rice caused polyneuritis (beri-beri) in fowls when used as a sole food, and the same rice when unpolished did not cause it. The disease was caused more slowly by a diet of pure corn starch (maize), and more rapidly by pure cane-sugar than by rice.

The main theories of the origin of beri-beri in vogue to-day are—(1) It is an infectious disease; and (2) it is due to a deficiency of some essential substance in the food. The infective theory has many good supporters, including Manson, Daniels, Wright, Scheube, Balz, Jeanselme, Le Dantec, and Marcheaux. Castellani[1] says: "It appears more likely that a parasite will be found the spreader of the disease, and the actual cause will be found to be a protozoon, than that it is due to the diet." The occasional occurrence of beri-beri in epidemics favours an infectious origin. Manson believes the actual cause of beri-beri is a toxin produced by a living germ, and the medium for its culture is outside the body; that it does not enter with the food or water, but is conveyed to man through the air or his skin. Rost[2] believes it is due to the consumption of rice, and the immediate cause is a diplobacillus developed in this cereal. He found this organism between the starch granules of mouldy rice; in the blood and cerebro-spinal fluid of beri-beri patients; and a culture of the organisms injected into fowls caused the same symptoms which they develop after eating mouldy rice. Kohlbrugge[3] isolated from rice a micro-organism, which he called *Bacillus oryzæ*, and a culture of it, when injected into fowls, caused polyneuritis in five days.

Shibayama communicated to the International Medical Congress at London, in July, 1913, an account of the study of the disease in Japan. He agreed that a beri-beri-like disease is caused in fowls by a diet of white rice, and alcoholic extract of rice-bran cures them. As to the cause of this disease, the Japanese disagree. Most of them hold that the disease is not caused by the deficiency of phosphorus or phosphorus-starvation, and hold that the true cause is a deficiency of something else. Tsuzuki attributes the disease to lack of aberic acid. Others support the zymotic hypothesis. They believe the disease is produced by a toxin developed by fermentation of white rice, and not from a deficiency of any kind of nutriment. This belief is based on experiments. Fowls which were injected with a fermentation product of white rice contracted a beri-beri-like disease. The heart of a frog immersed in this fermentation product of rice will stop in diastole, just as it will in the milk of a beri-beri woman.

The Japanese Commission made experiments in feeding human beings in groups. One group was provided with "cured" rice, another group with rice and barley, and a third with white rice.

[1] "Manual of Tropical Medicine," 1910, p. 888.
[2] *Brit. Med. Jour.*, 1902, ii. 831-833.
[3] *Centralb. f. Bakt.*, lx., 1911, 223.

The experiment was carried out twice in each place. The following table shows the results:

Main Diet.	Persons experimented on.	People who developed Beri-Beri.	Percentage of Beri-Beri.
Cured rice	657	8	1·22
Rice, 6 parts; barley, 4 parts ..	534	19	3·56
White rice	710	64	9·01

Thus neither cured rice nor barley prevented the disease entirely, though they seem to play a part. In another instance, also, these foods did not hinder the onset of the disease. In a group of 100 people fed with cured rice, 5 developed beri-beri; in 100 fed on rice and barley, 4; in 100 fed on white rice, 7.

Observations showed them that the disease never becomes epidemic in Japan, although a severe outbreak often occurs in villages, on ships, among coal-miners, fishermen, railway labourers, and prisoners. But they have not yet arrived at a conclusion as to its real cause.

But a careful examination of the records, of which Vedder has collected nearly a thousand, leads to the conclusion that the disease is not due to micro-organisms, but is due to a deficiency of essential substances in the food. This conclusion is supported by the researches of Eijkmann, Fraser and Stanton, Bréaudat, Grijns, Schaumann, Pol, Vedder, Chamberlain, Edie and Simpson, Casimir Funk, Strong and Crowell, and a long list of workers, who have shown that a deficiency of organic phosphorus and other organic substances leads to a lack of vitality and the manifestation of nervous and cutaneous symptoms.

The first authority to adopt the deficiency theory was Grijns,[1] who considers beri-beri arises whenever some substance essential for the metabolism of the peripheral nervous system is deficient in the food. Schaumann[2] believes that the disease is due to the absence of certain organic phosphorus compounds in the food. Eijkmann[3] had previously shown that animals fed on white polished rice developed a polyneuritis, which is considered the same disease as human beri-beri. He also found that unpolished red rice did not cause it; that polished white rice plus rice polishings did not cause it; and an aqueous extract of rice polishings cured the disease; whence it was inferred that rice polishings contain a protective substance, and further investigations showed that this protective substance was contained in that portion of the pericarp called by the Dutch the "silver skin." Bréaudat used rice polishings in the treat-

[1] *Gen. Tydschr. voor Nederl. Indie*, xli., 1901, and xlix., 1908.
[2] *Arch. f. Schiffs u. Tropenhyg.*, Heft 5, 1908, 37.
[3] *Virchow's Archiv*, cxlviii., 1897, 523.

ment of beri-beri, and cured many people. It has been stated above that Braddon, Ellis, and others found the use of uncured polished rice caused beri-beri; that parboiled or cured rice from the same sample did not cause the disease. Fraser and Stanton made the same observation. Moreover, it was found that when rice is cured prior to polishing, it is practically impossible to remove all the pericarp, and especially the "silver skin." Fraser and Stanton[1] obtained analyses of different rices which caused beri-beri, and they concluded that the percentage proportion of phosphorus was a valuable indication of the effects which would follow its consumption. They found rice bran is particularly rich in phosphorus, and the less phosphorus the rice contained, the more it was likely to cause beri-beri. This will be referred to again. Strong and Crowell[2] have conducted a long series of observations on prisoners and others with the object of determining whether beri-beri is an infectious disease or due to deficiency of some substance in the food. Every precaution was taken with regard to isolation, hygiene, and contamination of the food. They concluded beri-beri is not an infectious disease; it is only produced by means of diet, owing to the absence of some substance or substances essential to the physiological processes of the body. When such substances are absent from the food, beri-beri results. The prevention and cure of beri-beri in man only requires that he shall be supplied with a liberal and nutritious diet suitable to the needs of the body. The disease is cured by adding to the diet fresh meat, rice polishings or extract of the same, Katjang idjo beans (*Phaseolus radiatus*), yeast, and other foods which contain the deficient substances.

As Grijns was the first to suggest beri-beri is a deficiency disease, so was he the first to suggest the deficient substance is contained in the pericarp, and especially the "silver skin" of rice. It is now abundantly proved that rice bran contains the protective substance; and that this protective material is almost, if not entirely, removed from ordinary white polished rice. But it is not all removed from rice which is "cured," and unpolished red rice, or *padi*, contains the normal proportion. But the credit of having isolated the protective substance belongs to Casimir Funk, who obtained it after a long series of experiments. He has called this substance the "beri-beri vitamine." Rice contains but 1 part in 100,000; it is a most active substance, and rapidly cures beri-beri. It does not contain phosphorus, but it is thought this substance is necessary for the metabolism of the nervous system, and has some connection with the brain lipoids. An examination of the brains of pigeons suffering from beri-beri, by Funk,[3] showed that they are sensibly poorer in phosphorus and nitrogen than normal pigeons' brains, which suggests a degeneration of the lipoids. The same condition is found

1 Studies from the Institute of Medical Research, Federated Malay States, 1909, No. 10; 1911, No. 12; and *Lancet*, 1909, i. 451; 1911, ii. 1159.

2 *Jour. State Med.*, March, 1913, 129-150.

3 *Jour. Physiol.*, 1912, 50.

in the brain of starved dogs. Another problem is also suggested: In what form is the vitamine present in the food? Is it a lipoidal combination which is broken down by extraction from rice bran by alcohol, or is it adsorbed to the lipoidal fraction? These points are not settled. Funk[1] considers that "when the organism is healthy it does not matter whether it gets a fresh daily supply of lipoid or vitamine in the food . . . the body can use its own store. . . . But if there is a lack of vitamine in the body, and the organism is unable to synthetize it, it must get it ready-made from plants; and if it does not get it, deficient metabolism and death result. The synthetical power declines in general cachexia. The lack of vitamines in the food forces the animal to get this substance from its own tissues, and when the available stock begins to be scarce there is a breaking-down of nervous tissues, and the nervous manifestations of beri-beri result."

The foregoing account shows that the **treatment** of beri-beri includes the prescription of wholesome food of a natural character, containing a well-proportioned amount of protein, fat, and carbohydrate, and the exclusion of dried, pickled, canned, processed, or autoclaved foods. The use of cured or parboiled rice is curative, as well as red rice and extract of the rice polishings. Hongo beans (Katjang idjo beans, *Phaseolus radiatus* Linn) are vaulable as a food; they contain a good proportion of the protective substances, and are more readily obtained than extract of rice bran. Yeast may be given freely. Pineapple juice is held to be of value. Although the beri-beri vitamine probably differs from the scurvy vitamine, the use of fresh potatoes, onions, and other fresh vegetables, may be useful, especially in outbreaks like that in Brazil (*vide supra*). In fulminating cases of beri-beri in adults it seems desirable to use extract of rice polishings; and this extract will cure the disease in infants, who are unable to consume the other foodstuffs, even when fresh milk is unobtainable. The conclusions derived from all the investigations of beri-beri show that beri-beri in man can be prevented and cured by the consumption of liberal and nutritious diet of the ordinary kinds planned to meet the physiological needs of the body.

Pellagra.—This disease has long been associated in the minds of men with the consumption of Indian corn or maize. There are many theories respecting its origin, and authorities are chiefly divided into Zeists, or those who hold the maize theory, and Zymologists, or those who hold that the disease has a zymotic or infective cause. The various theories are briefly as follows:

1. *The Intoxication Theory.*—That the disease is due to the presence on maize of fungi which secrete toxins. Aspergillus and penicillium are constantly found on spoilt corn, and the supporters of this theory believe their toxins cause pellagra.

2. *The Photo-Dynamic Theory.*—The cutaneous manifestations of pellagra occur chiefly in parts of the body exposed to light. A

[1] *Jour. State Med.*, 1911, 350.

similar condition, known as "fagopyrismus," also occurs in white or partly white animals fed on buckwheat who are exposed to light; they become paralyzed, and die in a short time. This suggested to Raubitschek[1] that these diseases have a photo-dynamic origin, due to sensitization of the skin by lipoids. Maize is the richest of all cereals in lipoids, and Raubitschek considers that under the influence of sunlight a poison is developed from maize lipoids which affects not only the skin, but the whole organism.

3. *The Infectious Theory.*—A micro-organism, which they called *Streptobacillus pellagræ*, was isolated from the fæces and organs of pellagrins by Tizzoni and Panichi,[2] which they found on spoilt corn; but cultures of this microbe only caused pellagra in guinea-pigs when they were fed with maize. Bass,[3] of Tulane University, also isolated and cultivated bacteria from fæces and other excretions of pellagrins; fowls fed with maize on which the bacteria were cultivated developed definite pellagrinous symptoms. Raubitschek[4] submitted to bacteriological tests samples of sound and unsound maize; no micro-organisms which he found on maize, when injected into experimental animals, gave any results comparable with pellagra, and he concluded the bacterial origin of the disease was disproved. Sambon,[5] after a careful inquiry in Italy, came to the conclusion that pellagra is not necessarily a food disease or connected with the consumption of maize, and he believes it is due to protozoa transmitted to man by a biting fly, and most probably by the buffalo gnat, sand-fly, or black-fly (genus *Simulidæ*). The *Simulidæ* are widely distributed throughout the world; they breed in mountain streams and other swift-running currents, and cause great destruction among horses, cattle, sheep, poultry, etc. This theory is now being investigated by many men in various parts of the world. According to the British Pellagra Commission, 1910, there are in Italy 60,000 cases of pellagra, in Roumania 50,000, and it is estimated that in the United States of America there are at least 50,000 cases, of which 10,000 have been satisfactorily diagnosed; and during the last few years it has been found indigenous to the British Isles, more than fifty cases having come to light, where it was previously considered to be non-existent.

Bearing upon this theory of the transmission of pellagra, the investigation of the distribution of the *Simulidæ* in Illinois is important. Louis W. Sambon announced his theory in 1905, and elaborated it in the *Journal of Tropical Medicine and Hygiene* in 1910. In the latter year the Governor of Illinois appointed a State Commission to inquire into the causes of pellagra in the asylums and other institutions of that State. Stephen A. Forbes, whose duty it is to investigate insects injurious or dangerous to the public

[1] *Wien. Klin. Woch.*, 1910, 963.
[2] *Centralb. f. Bakt.*, 1907, i. 210, and 1908, i. 310.
[3] *Jour. Amer. Med. Ass.*, 1911, ii. 1684.
[4] *Centralb. f. Bakt.*, 1911, 193.
[5] *Brit. Med. Jour.*, 1905, ii. 1272.

health, made observations with regard to *Simulidæ*. There are about 500 cases of pellagra known to exist in Illinois, of whom 63 per cent. were in the hospital for the insane at Peoria. There are five other asylums and one almshouse in the State, with cases of pellagra in each. Therefore the occurrence and abundance of *Simulium* in their neighbourhood is a matter of great importance in view of their probable connection with the disease. A most searching investigation was made. Forbes[1] says there are seventy species of *Simulium* known in the world; of these fifteen are found in America; nine (possibly ten) have been found in Illinois. Only one European species, *S. hirtipes*, has been found in America; and *S. reptans*, the species implicated by Sambon, does not exist in North America, although it is reported in Greenland. The *Simulidæ* are all biting flies, a great nuisance and destructive pest. In Illinois they do not breed exclusively in swift-running streams; there is scarcely a small stream anywhere, including roadside ditches, in which *Simulium* larvæ cannot be found in spring and summer—in fact, *Simulium* is more completely and uniformly distributed in Illinois than *Anopheles*, but there is no part of the State permanently free from malaria, and there would be no part of it free from the danger of pellagra if that disease is really transmitted by *Simulidæ*. It is one of the main lines of Sambon's argument that the distribution of pellagra is limited by the distribution of *Simulium*. But in Illinois *Simulium* is generally distributed; pellagra, on the other hand, is distinctly local. The seasonal periodicity of pellagra is seen in Illinois, as elsewhere. Therefore, if *Simulium* transmits the disease, there should be a correspondence between the abundance of insects and the number of new cases of pellagra. But there is no agreement between seasonal variations of the disease and the insects. The actual number of *Simulidæ* on the wing is greatest in the spring; after the spring outburst their number diminishes rapidly, so that it is usually difficult to find an adult *Simulium* in August and September even in places which they rendered uninhabitable in April and May. The new cases of pellagra in Illinois occurred in waves, and they were studied in connection with the *Simulium*. Forbes[2] says: "At one time I believed we might make out a relation of succession between the successive waves of increase in the disease and successive generations of *Simulium*, but as my data accumulate, this relationship becomes decidedly doubtful, and the pellagra periods certainly cannot be connected with any seasonal differences in the abundance of *Simulium*." Sambon endeavours to associate the summer and fall recrudescence of pellagra with the summer and fall abundance of *Simulium*, which draw the hypothetical protozoon from the blood of pellagrins. But Forbes[3] finds it impossible to correlate this periodicity with the facts regarding the development of *Simulium* in Illinois. Moreover, Sambon considers pellagra a

[1] *Science*, 1913, xxxvii. 87. [2] *Ibid.*, xxxvii. 90. [3] *Ibid.*

rural disease, affecting field workers chiefly, town dwellers being immune; but in Illinois 96 per cent. of the patients had lived in or near large towns and cities. While taking a severely critical attitude towards the *Simulium* theory, Forbes did not consider the data obtained in Illinois were conclusive either for or against it.

The *Simulium* theory was also strongly criticized by Beall;[1] he investigated fifty-four cases of pellagra in Texas, and did not consider it probable that *Simulidæ* were connected with their causation. As a matter of fact, only four persons afflicted by pellagra lived within a mile of a stream, forty-one lived more than one mile away, two lived eight miles, four lived ten miles, one lived twelve miles, and two above fifty miles, from a stream. The average distance of the patients from running water was four miles; in fact, he found pellagra was prevalent in places where the nearest running water is miles away, and in spite of three years' drought the number of cases of pellagra was markedly increased. Hunter[2] considered that, if sand-flies (*Simulidæ*) were the cause of pellagra, it should be possible to obtain experimental pellagra by using them. These *Simulidæ* breed in the streams in Kansas, and have been found near the homes of pellagrins. He fed the flies on pellagrins, and then on guinea-pigs and monkeys, but only got negative results.

Although *S. reptans* does not exist in America, there are other biting flies and insects, and an investigation was made with regard to them. Jennings and King[3] studied the relationship of insects and pellagra in Spartanburg County. They inspected the premises and neighbourhood of pellagrins to discover the presence, distribution, and biology, of insect groups. In some instances their investigation was extended to the houses of persons free from pellagra, for comparative purposes. It should again be pointed out Sambon found the disease chiefly in field labourers. In Spartanburg County, Jennings and King investigated 282 cases—75 per cent. were females, 173 were adults, and 82 per cent. were occupied chiefly in housework. They investigated ticks, lice, bed-bugs, cockroaches, fleas, house-flies, horse-flies, stable-flies, buffalo-gnats, sand-flies, and mosquitoes. They concluded that all these insects might be eliminated from the search except house-flies and stable-flies. They consider house-flies should be regarded with suspicion until the transmissibility of pellagra is disproved, or the nature of the virus and the mode of dissemination is discovered. But the stable-fly (*Stomoxys calcitrans*) is believed by them to have characteristics qualifying it for the rôle of transmitter of the disease. Its range covers that of pellagra; the seasonal activity is coincident with that of the disease. It bites only by day, which they consider accounts for the age and sex incidence of pellagra; and the highest percentage of reports of bites by *Stomoxys* was received by them from mill villages, where they had found the greatest proportion of pellagrins.

1 *Jour. Amer. Med. Ass.*, 1911, ii. 1683. 2 *Ibid.*, 1912, i. 547.
3 *Ibid.*, 1913, i. 1948; and *Amer. Jour. Sci.*, September, 1913.

An extensive study of pellagra in the Southern States of America was made by Grimm.[1] Pellagra is constantly increasing in the districts he visited; he found more cases of pellagra among whites than negroes, more among females than males, more in conditions of poverty than comfort, more in small towns and villages than in rural districts. The cases were grouped together, and the mortality was highest in negroes. The possibility of some insect playing a part in the dissemination of the disease is not inconsistent with his observations. The relationship between the food consumed and the disease admitted of no present conclusion. The relationship between pellagra and the food appears to be a real one, but whether the food acts merely as a predisposing cause, or whether certain articles of food are the real exciting cause, or only exaggerate the symptoms, is an open question; it is possible certain foods act in all three ways.

4. *The Deficiency Theory.*—The theory that pellagra is associated with the consumption of maize has not given place to any theory supported by an equal weight of evidence. Box[2] says the main arguments for the zeistic theory are—(1) Pellagra was recognized in Europe after the introduction of maize, and followed the cultivation of the new foodstuff; (2) it is only endemic where maize is used extensively as an article of food; (3) when maize is eliminated from the diet, pellagra diminishes or disappears. In his essay on the Deficiency Diseases, Casimir Funk[3] says: "It is beyond doubt that pellagra has a close connection with maize." He considers it is due to deficiency of vitamines in the food, that vitamines exist in the outer layers of maize, and the outer layers or pericarp are removed in milling. The peasantry of Italy live on a diet in which vitamines are deficient. In winter their food consists chiefly of maize-meal, chestnut-meal, macaroni, beans, fish, and lard; in summer, maize-meal (or polenta made from it) is partly replaced by bread, in which maize-meal preponderates. This dietary is deficient in protein. Observations on peasants and students were made by Rubner, and in each case he found the diet defective. The actual diet consumed by two peasants and their nitrogen balance was as follows: A consumed 1,723 grammes of polenta, soup, herring, and olive-oil; the nitrogen in the food was 14·8, in urine 13·0, in fæces 3·0, and the deficiency 3, grammes. B consumed 1,383 grammes of polenta, some soup, a herring, and olive-oil; the nitrogen in the food was 11·2, in urine 9·3, in fæces 2·5, and the deficiency 0·6, grammes.

The maize theory receives considerable support from a recent account of the results of feeding in South Africa by Nightingale.[4] Forty cases of pellagra occurred in a prison; this institution is a mile away from a river which is in flood for three months each year, sluggish for the next five months, and reduced to pools for the

[1] *Jour. Amer. Med. Assoc.*, April 5, 1913.
[2] *Practitioner*, 1913, i. 940.
[3] *Jour. State Med.*, 1912, 341-368.
[4] *Brit. Med. Jour.*, 1914, i. 300.

rest of the year. It is more likely to be a breeding-ground for malarial mosquitoes than for *Simulium reptans*. The occurrence of the disease was distinctly associated with a diet consisting largely of corn-meal (*mealie-meal*). The early gastro-intestinal symptoms closely resembled those of pellagra and beri-beri, and the latter cutaneous manifestations resembled those of pellagra. The meal was ground sufficiently fine for 75 per cent. of the cereal to pass through a twenty to the inch bolter or sieve. The bran was fed to cows, and greatly increased the quantity and quality of their milk. After the occurrence of this outbreak the use of corn-meal was stopped. The diet was replaced by meat, vegetables, rice, and rapoko-meal. Rapoko-meal consists of the seeds of *Eleusina corcarana*, which is coarsely ground and used by the natives. Under this diet the patients improved, but when they returned to corn-meal (*mealie-meal*) relapses occurred. The conclusion derived by Nightingale from his observations was that zeism or pellagra arises from the use of maize or corn as a staple diet.

Important commissions are now working on pellagra in Europe, America, and other countries. A report on the work of the Thompson-McFadden Pellagra Commission in South Carolina is given by Siler and Garrison.[1] They found 1·42 cases of pellagra in each family. Corn-meal (maize) is the staple food; it formed 84 per cent. of the daily diet in rural cases, and 74 per cent. of the diet in urban cases. But they found pellagrous children who had eaten no corn for two years, and several adults who had eaten very little. The Pellagra Commission in Illinois found no marked deficiency of the diet in 500 cases. In one house in Peoria[2] fifty-six people were fed for a year with a diet in which corn predominated, and in another house fifty-six were fed on similar diet, and received no corn; but the number of cases of pellagra in each house were nearly equal.

The importance of the maize theory is obvious when it is stated that this cereal forms the staple food of many millions of people, and, it is asserted, enters into the composition of no less than 135 food articles of commerce. Casimir Funk[3] finds modern methods of milling alters the chemical composition and nutritive value of the meal. In maize, as in rice, the vitamines are chiefly in the outer layers, and these are removed. The mode of preparation varies in different countries, and the manifestations vary from mild to severe. It would be preferable if the whole grain were used, as in the ancient modes of grinding. But adequate reasons have been given for modern methods. When the germ and much fat is left in the meal, the fat goes rancid and the meal becomes unpalatable.

The chief evidence against the maize theory is that pellagra occasionally afflicts people who have never eaten corn in any way, and that people who have eaten corn and even spoilt corn for long periods often fail to contract the disease. During the American

1 *Amer. Jour. Sci.*, 1913, ii. 42.
2 Zeller, *Jour. Amer. Med. Assoc.*, lvii., 1911, 1688.
3 *Jour. Physiol.*, 1913, 389-392

Civil War corn-meal was one of the principal foods of the soldiers, and it was often spoilt; but careful inquiry fails to show that pellagra was prevalent among the soldiers. Much interest was aroused by the discovery that pellagra is indigenous to Great Britain, and this fact, without any experimental inquiry, appears to prove that maize-eating cannot be the only cause of pellagra, seeing that this cereal is consumed very sparingly in the British Isles. Babcock suggests that pellagra may be due to a monotonous diet of any sort, especially such as is used in charity institutions. Whether it simply arises from malnutrition, like scurvy and beri-beri, remains to be shown. As regards the *dietetic treatment* of the disease, a well-balanced mixed diet of ordinary fresh foods seems to be all that is required. The precaution of excluding corn-meal from the diet of pellagrins is suggested by the observation that the disease is often associated with the consumption of this article of food.

THE CHEMICAL NATURE OF THE VITAMINES.—An exhaustive analysis of the work of many investigators led Schaumann to the conclusion that tropical beri-beri, ship beri-beri, experimental beri-beri, scurvy, and allied diseases are due to a deficiency of organic phosphorus in the food. Experimental beri-beri or polyneuritis can be produced in fowls, pigeons, ducks, guinea-pigs, rabbits, rats, cats, dogs, and apes. The disease is very easily produced in pigeons and fowls in whom metabolism is very rapid; but less easily produced in rats, especially young ones, who have a large store of phosphorus, and are more resistant to the disease. The disease is caused by consuming cereals (rice, barley, wheat, and oats), from which the outer layers of the grain have been removed by milling, flour or bread made from them, and boiled milk, tinned meat, and other foods heated to 120° C. or more. There is a difference in the phosphorus content of these foods. In cereals the greater portion is in the outer layer; boiled milk and tinned meat have a considerable part of their organic phosphorus destroyed. The following table shows the phosphorus and nitrogen in foods used in the observations on beri-beri by Strong and Crowell[1] of the Biological Laboratory of the University of the Philippine Islands:

Kinds of Food.	P_2O_5.	Nitrogen.
	Per Cent.	Per Cent.
Bacon	·21	·7
Onions	·7	1·8
Codfish (dried)	2·9	10·58
Starch	trace	·18
Sugar	trace	2·11
Potatoes	·23	·31
White rice	·37	1·25
Red rice	·69	1·16
Rice polishings	4·47	1·80
Alcoholic extract of rice polishings	·025	·365

[1] *Jour. State Med.*, 1913, 136.

Edie and Simpson[1] found fresh milk contains 1·0 per cent. P_2O_5, skim milk 0·03, rye 1·0, oatmeal 0·9, and white bread 0·2, per cent. of P_2O_5, mostly in an organic combination.

The arguments in favour of the phosphorus deficiency theory of Schaumann are—(1) The fact that foods which cause beri-beri, ship beri-beri, scurvy, and infantile scurvy are deficient in organic phosphorus; and (2) the diseases are cured by foods rich in organic phosphorus compounds. It is probable that different groups of organic phosphorus compounds serve different purposes in the organism, and their absence leads to different diseases. Deficiency of one organic group may cause beri-beri in adults, deficiency of another group may initiate osteomalacia in pregnant women, and deficiency of a third group may cause rickets and infantile scurvy. Children fed with boiled or condensed milk develop scurvy-rickets. When milk is boiled, it is to some extent denatured; the organic compounds of phosphorus are more or less destroyed. Bunge says lecithin is destroyed at 70° C. (140° F.). Raczowski found 25 per cent. was destroyed at 60° C., 28 per cent. at 95° C., and 30 per cent. at 110° C. Rickets is common in children of the poor in England, less common in the Highlands of Scotland and in Ireland. Many English children are fed on skim milk containing only 0·03 per cent. of P_2O_5 white bread containing 0·2 per cent. P_2O_5 and margarine. A Scotch Highland child gets oatmeal containing 0·9 per cent. P_2O_5 and new milk containing 1·0 per cent. P_2O_5; and German children get rye bread containing 1·0 per cent. P_2O_5. Edie and Simpson[2] found that these diseases are not cured by the addition to the food of carbohydrates, inorganic phosphates, egg-albumin, and *synthetic* organic phosphorus compounds, such as glycerophosphates, albumin metaphosphates, etc., nor did these substances prevent polyneuritis in birds. But polyneuritis (beri-beri) in birds is prevented and cured by the addition to the diet of substances rich in organic phosphorus, such as rice-bran, wheat-bran, yeast, Katjang idjo beans, testicular extract, pancreas, etc., in such proportion as to raise the daily income of phosphorus in the food to the normal amount. The daily normal requirement for a man is 2 grammes, for a dog 0·5 gramme. It was found by Fraser and Stanton[3] that the beri-beri causing power of rice is associated with the removal of the phosphorus-containing substances by polishing the grain. They have definitely proved that no rice connected with the outbreak of beri-beri contained more than 0·26 per cent. of P_2O_5, that rice which contained 0·37 per cent. of P_2O_5 did not cause beri-beri, and the consumption of rice containing 0·4 per cent. of P_2O_5 is perfectly safe. According to Fraser and Stanton, unpolished red rice contains an average of 0·54 per cent. of P_2O_5, and Aron found 0·557 per cent. More recent evidence is afforded by a Siamese Government Report on beri-beri by Highet, which furnishes conclusive evidence that the use of rice containing less than 0·4 per

[1] *Brit. Med. Jour.*, 1911, i. 1421. [2] *Ibid.*, 1911, i. 1422.

[3] Studies from Institute of Medical Research, Federated Malay States, 1909, No. 10; 1911, No. 12; and *Lancet*, 1909, i. 451; 1911, ii. 1159.

cent. of P_2O_5 is likely to cause beri-beri. If not milled so as to reduce the P_2O_5 below this standard, Siamese rice is a safe food. Acting on this finding, the Siamese Government pushed the use of under-milled rice in all Government institutions and the gendarmerie, and has practically done away with beri-beri among these people, and an attempt is now being made to enforce its use in the army and navy.

Beri-beri does not occur as a rule in those who consume cured or partly milled rice which yields 2·5 to 4·5 grammes of P_2O_5 per man per day. But occasionally it occurs in people whose diet contains enough phosphorus. This is probably due to gastro-intestinal catarrh. It is noteworthy that this disease sometimes reduces the absorption of food one-half or two-thirds. Moreover, the bacteria of the alimentary canal destroy organic phorphorus compounds, lecithin being reduced to neurin, cholin, and other substances. When nursing-infants suffer from beri-beri, the mother's milk is deficient in organic phosphorus. The infant may give evidences of beri-beri before the mother, because the woman's organism husbands her store of phosphorus at the expense of the milk.

The great importance of organic phosphorus is shown by the fact that half the P_2O_5 in milk consists of organic compounds. The animal organism stores phosphorus in the times of plenty to meet the demands in times of stress, and there is no class of materials, not even protein, which the organism husbands more carefully than its stock of organic phosphorus. The organic forms of phosphorus are nucleins, nucleic acids, phosphatides (lecithins), cholesterol (cholesterin), cerebrosides (cephalin, cerebrin), phytin in plants, phosphocarnic acid in meat, and other substances not yet defined. It has already been stated that Schaumann,[1] having made an exhaustive analysis of the work of many men, and in consequence of his own researches, concluded that beri-beri and the allied diseases are caused by a deficiency of these organic phosphorus compounds in the food. He still maintains that opinion, and it is strongly supported by the investigations summarized above. The power of yeast to cure beri-beri had been proved by many men. It is rich in organic phosphorus, and Schaumann endeavoured to discover which of the compounds had a curative effect. He tried the individual constituents, such as lecithin and nucleic acid, but without obtaining satisfactory results. It was subsequently shown by Eijkmann that the protective substance of yeast could be extracted by 88 per cent. alcohol, and such extract was curative, but its nature was not exactly determined. Later on Casimir Funk[2] hydrolyzed pressed yeast with 20 per cent. sulphuric acid, and obtained a solution which retained the curative power of yeast, and it was a nitrogenous substance precipitated by phosphotungstic acid. Funk obtained the vitamine from this precipitate, and found it was separable into several substances possessing different melting-points and solubilities.

[1] *Archiv f. Schiffs. u. Trop. Hyg.*, 1910, Heft 8.
[2] *Brit. Med. Jour.*, 1913, i. 814.

Edie, Simpson, Moore, and Webster[1] obtained a similar substance from yeast, which on purification yielded feathery crystals having a definite formula.

Katjang idjo beans, which have been found so valuable in the treatment of beri-beri, were then submitted to an exhaustive examination. Pol found an aqueous extract of the beans was curative after a precipitate thrown down by lead acetate was removed, and from the remaining clear solution a crystalline substance was obtained. Attention was then turned to rice. Polished rice causes beri-beri; the rice-bran or polishings cure it. The principal organic substance in rice-bran is phytin; it forms about 33 per cent. of the alcoholic extract. Experiments were made with phytin to discover any curative effect it might possess. Aron and Hocson claimed very satisfactory results from its use; but Eijkmann, Schaumann, Cooper, and Funk did not get satisfactory results. Rice-bran also contains lecithin, nuclein, nucleic acids, etc., and Schaumann had previously experimented with these individual substances without getting the desired results. Ternuchi prepared an extract of rice-bran, *removed the phytin*, evaporated the solution, and extracted the residue again with alcohol. This latter alcoholic solution was curative, but it contained very little phosphorus, and it was concluded that phytin neither prevented nor cured beri-beri. Eijkmann made an aqueous extract of the "silver skin," which is richer in nitrogen than any other part of rice; and after eliminating phytin, this aqueous extract also contained the protective substance, which proved to be dialyzable and not precipitated by alcohol. Schaumann[2] concluded that the protective substance is not phytin, but it is impossible to allow that beri-beri is due to deficiency of any of the primary constituents of the diet. He asserts, however, that the protective substances are all rich in phosphorus, although they have not been defined. He, like others, isolated from rice-bran certain curative substances which contain nitrogen, but no phosphorus; he believes these substances are activators or hormones which produce changes in the organic constituents of the nerves. Funk made a systematic investigation of the components of rice-bran. The different fractions obtained were tested on pigeons suffering from beri-beri or polyneuritis, and finally he obtained the beri-beri vitamine. The proportion of this substance in rice is exceedingly small—1 in 100,000, or 1 gramme per kilo. It is an organic base, precipitated by phosphotungstic acid, silver nitrate, and barium hydroxide. It is partly precipitated by mercuric chloride in alcoholic solution in the presence of cholin, and is not precipitated by platinum chloride in solution. It yields a crystalline nitrate containing $C_{55 \cdot 63}H_{5 \cdot 29}N_{7 \cdot 68}$ per cent.[3] and having the formula $C_{17}H_{20}N_2O_7$.[4] It is soluble in water, alcohol, and acidulated alcohol, and is destroyed by a temperature of 120° C. The dose is

1 *Phil. Jour. Med. Sci.*, 1912, 423.
2 Trans. Soc. Trop. Med. and Hyg., 1911, 59.
3 *Jour. Physiol.*, 1911, 395-400.
4 *Jour. State Med.*, 1912.

very small; 40 milligrammes is sufficient to cure a pigeon of beri-beri polyneuritis in a very short time, often in three hours; and its administration prevents beri-beri in pigeons and other animals. Funk's beri-beri vitamine has been strongly criticized, and some authorities consider that the "isolation and identification of the active substance in beri-beri remains for the future," and Funk has, in their opinion, "failed to isolate it in a pure state." Vedder[1] agrees with Funk that the actual preventive substance is not a phosphorus compound, as thought by Schaumann; it is probably a base derived from nucleic acid; but he considers the exact composition of that base is at present unknown, several formulæ having been given. Probably there are several active substances essential to man and animals, substances required in very minute proportions, and which for want of a better term are called "vitamines." Umetro, Shinamura, Tsuzuki, and Odoke[2] isolated from rice-bran a substance they called **oryzanin**. They consider this substance is widely distributed in various foodstuffs; and whenever it is deficient, the diet is insufficient to support life. If it is added to an artificial diet of fat, protein, carbohydrate, and salts, from which it is absent, the diet becomes sufficient. When birds, mice, and other animals have become seriously ill and emaciated from being fed exclusively with white rice, they rapidly recover after the addition of oryzanin to the food. Dogs wasted rapidly when fed on white rice, and speedily recovered when they received 0·3 gramme of oryzanin daily. Still working at the subject, Tsuzuki[3] isolated from rice-bran another substance, which he called **aberic acid**, of which a daily dose of 0·005 milligramme effectually protects pigeons and other small animals, fed exclusively on white rice, from beri-beri. Moore[4] agrees with Funk that the protective substance in the subpericarpal layers of rice is not a phospho-protein, he considers it a glucoside—probably a galactan. He prepared an alcoholic extract of rice-bran by the method described by Chamberlain and Vedder; it was active in curing pigeons of polyneuritis, due to feeding on white rice; it contained 4 milligrammes of nitrogen, but only 0·16 milligramme of P_2O_5 per cent.; it yielded no pentoses on hydrolysis, but it yielded a reducing sugar, whence he concluded the protective substance is a glucoside.

The absence of phosphorus from Funk's beri-beri vitamine is against Schaumann's phosphorus deficiency theory. But the latter should not be given up without further investigation. Ship beri-beri is common in sailing-vessels when the men are put on bread, biscuit, rice, dried potatoes, and pickled meat. Pickled meat loses half its organic phosphorus by the decomposing effect of the lye; and the other part of the diet is manifestly deficient in phosphorus. When examined on landing, the excretion of phosphorus by such

1 "Beri-Beri," Bale, Sons and Danielsson, 1913.
2 *Zeit. f. Biochem.*, xliii., 1912, 89-153.
3 Shibayama, Internat. Med. Cong., London, 1913.
4 *Brit. Med. Jour.*, 1911, ii. 1137.

sailors is only half the usual amount; but they recover rapidly when given a diet of fresh meat, fresh vegetables, yeast, Katjang idjo beans, testicular extract, and other substances rich in organic phosphorus.

With regard to wheat flour and bread, experiments have shown that small animals grow faster, bigger, and breed larger families with standard bread and wholemeal flour than they do when fed with white bread and flour. White flour is deprived of the bran, cerealin, and germ of the grain. In the germ are lecithins, nucleins, nucleic acids, nucleo-proteins, and basic proteins, all rich in phosphorus; aleurone contains the same kind of bodies, but more phosphorized fat. The phosphorus in wheat bran was formerly thought to be chiefly in the form of inorganic phosphate of lime, magnesia, and silica. Later on it was considered to be chiefly in the organic phosphorus compounds. More recently it was shown by Patten and Hart that only 33 per cent. of the phosphorus in bran is organized; and the chief remaining phosphorus compound is a magnesium-calcium-potassium salt of a phospho-organic acid—namely, anhydro-oxymethylene-diphosphoric acid — a substance which is widely distributed in the vegetable kingdom.

The scurvy vitamine is different from the beri-beri vitamine; it is a crystalline substance, destroyed by a temperature of 120° C. or less, contained in fresh potatoes, onions, cabbage, dandelion-leaves, apples, lemons, limes, lime-juice, etc. It is much less stable than the beri-beri vitamine. Only fresh foods contain it; drying, canning, and processing the foods destroys it. The vitamine of cabbage is destroyed at 110° C. That of lime-juice is more stable; it is not destroyed by boiling the juice for one hour, and this, although the proportion is very small, afforded one of the best vitamines for experiments. Oats, barley, and other cereals, if unhusked, develop the scurvy vitamine during germination; but the protective power is lost when the grain is dried and again developed in the presence of moisture if the temperature is not too high.

The vitamines of milk are destroyed by heat, but their composition is unknown. Stepp found that mice fed on milk from which fat had been removed by ether died after a short time, but the addition of the ether extract kept them alive a long time (p. 613). This is the foundation of the theory that the vitamines of milk are associated with the butter-fat fraction. The vitamines are destroyed by boiling, by peroxide of hydrogen, and other substances. Osborne, Mendel, Ferry and Wakemann[1] also considered the vitamines of milk are to be found in the butter-fat fraction. But Osborne and Mendel[2] had previously fed rats on protein-free and fat-free milk, and it did not cause the growth to cease; the rats grew on a diet completely free from fat, or which did not contain any significant amount of phosphatides and cerebrosides. But it has been shown that milk contains a growth vitamine and a scurvy vitamine. Com-

1 *Jour. Biol. Chem.*, 1913, 423-437.

2 *Ibid.*, 1912, 82-89.

mercial dried milk yielded a vitamine which cured small animals of beri-beri; therefore Funk believes that milk contains several vitamines different from each other. The scurvy vitamine was not found in dried milk; it is probably destroyed by concentration at too high a temperature. The composition of these substances is unknown, but the instability of the protective substances in milk suggest that it should not be boiled or heated more than it can bear.

It is thus shown that the question of vitamines is very far-reaching. It involves bread, all kinds of farinaceous foods prepared for infants and invalids, milk and all the commercial preparations, including many infants' and invalids' foods, malt extracts vegetable and meat extracts, eggs, cereals, canned foods, etc. An authority, writing to me on the subject, says: "Suppose the recent contention that the growth-producing vitamine of milk is connected with the butter-fat fraction be correct, such a fact may have far-reaching and unlimited significance and effects, perhaps in directions we do not anticipate. And bearing on this point, a certain food is advertised to contain the vitamines of milk, but has a fat-content of only $\frac{1}{3}$ per cent.! The food is recommended to be taken with cream!! It should be said the statement appeared before the investigation" (see Stepp, p. 613).

THE INSUFFICIENCY OF CERTAIN PROTEINS.—We now come to a different view of the cause of deficiency diseases—a view which is highly important and requires further elaboration. The study of nutrition hitherto has consisted largely of statistical accounts of the income and outgo of matter and energy. But the conception of digestion as the act of solution of the food has given place to the knowledge that intricate chemical changes occur in the alimentary canal. In fact, no sooner did the isodynamical law of foods find general acceptance than its practical limitation became the subject of inquiry. The proteins in particular have been criticized. The idea that all proteins have not an equal value is not a new one; it has long been known that gelatin is not equal to casein or albumin. But the knowledge that all proteins differ only became recognized after a careful study of the amino-acids resulting from their hydrolysis. It is now known that all proteins consist of amino-acids, many of the same acids, but they are not combined in the same proportions. This is clearly shown in the table on p. 610. The proportion of amino-acids in edestin and glutenin differs so much as to raise the question of their comparative nutritive value. Zein, hordein, and casein lack some of the amino-acids found in others. Indeed, it is probable that for the maintenance of growth and repair, and the well-being of the organism, a minimum of certain amino-acids is requisite. This subject has been studied by Osborne, Mendel, and others, and has a bearing on the question of maize as a cause of pellagra. Until recently it has been almost impossible to study the food value of isolated proteins and amino-acids owing to the inability to obtain them in a state of purity. Moreover, feeding

AMINO-ACIDS IN PROTEINS.

100 Grammes of Protein yield—	Fibrin.	Globin from Hæmo-globin.	Serum Albumin.	Serum Globulin.	Casein.	Edestin from Hemp-seed.	Gelatin.	Elastin.	Horn.	Histon.	Zein.
	Grammes.	Grammes.	Grammes.	Grammes.	Grammes.	Grammes.	Grammes.	Grammes.	Grammes.	Grammes.	Grammes.
Glycocoll	3·0	—	—	3·52	0·00	3·80	16·50	25·75	·34	·5	0·00
Alanin	3·6	4·19	2·69	3·22	1·50	3·60	·80	6·58	1·20	3·5	9·79
Leucin	15·0	29·04	20·00	18·70	9·35	20·90	2·10	21·38	18·30	11·8	19·55
Prolin	2·5	2·34	1·04	2·76	6·70	1·70	5·20	1·74	3·60	1·5	9·04
Phenyl-alanin ..	2·0	4·24	3·08	3·84	3·20	2·40	·40	3·89	3·00	2·2	6·55
Glutaminic acid ..	8·0	1·73	1·52	2·20	15·55	6·30	·88	·76	3·00	·5	26·17
Aspartic acid ..	2·0	4·43	3·12	2·54	1·39	4·50	·56	—	2·50	—	1·71
Cystein	—	·31	2·30	·67	—	·25	—	—	—	—	—
Valin	1·0	—	—	—	7·20	—	—	1·00	—	—	1·88
Serin	present	·56	·60	—	·5	·33	—	—	5·70	—	1·02
Oxy-prolin	—	1·04	—	—	·23	2·00	3·00	—	—	—	—
Tyrosin	3·5	1·33	—	—	4·50	2·13	—	·34	·68	5·2	3·55
Lysin	—	4·28	—	—	3·95	2·00	2·75	—	—	6·9	0·00
Arginin	—	5·42	—	—	3·81	11·80	7·62	·30	2·25	11·5	1·55
Histidin	—	10·96	—	—	2·50	1·00	·40	—	—	1·5	·82
Tryptophane ..	—	present	present	present	1·50	present	—	—	—	—	0·00
Diamino-tri-oxy-do-decanic acid ..	—	—	—	—	·75	—	—	—	—	—	—

with isolated foodstuffs is so costly, and the investigations so laborious, that it is only possible when supported by a wealthy institution. Great praise is due to Professors Osborne and Mendel,[1] for their researches, and the thanks of the scientific world are due to the Carnegie Institution of Washington, which provided the means.

White rats were fed with artificial food of uniform composition during a large span of their life; body-weight was the index of their nutritive condition. A distinction was made between maintenance and growth. A man who maintains his weight may be in excellent condition, but a child who does likewise *fails to grow*. Childhood demands a ration which will supply material for growth as well as maintenance. With this proviso it was asked, Can life be maintained and is growth possible with a single protein in the dietary? It was found that with casein, legumin, edestin, and gliadin, grown rats were kept alive and maintained their weight for long periods. But with zein, the chief protein in maize, a decline in the nutrition and weight of adult rats was apparent from the outset. Nor did the rats fare better when zein was combined with other proteins.

With young rats the effect was remarkable. With an appropriate mixed diet their growth was vigorous. But when fed with diets containing a single protein, they *failed to grow*, although they maintained their weight and size for a long period. Here, then, is a distinction between maintenance and growth. The capacity for growth was not lost to these animals; this was shown by the fact that they grew and produced young after being fed on a mixture containing milk-powder. Obviously, this preparation of milk-powder contained the necessary element to promote growth. Therefore they used a preparation of this milk-powder to prepare protein-free and fat-free milk for use in connection with isolated proteins. By using this protein-free milk to supply the accessory portions of the diet, they were able to prove that there was adequate growth when the sole protein consisted of casein, lactalbumin, crystallized egg-albumin, edestin from hempseed, glutenin from wheat, and glycinin from soy-beans. But not all proteins suffice to promote growth under otherwise favourable conditions. Gliadin (notably lacking in glycocoll and lysin), and hordein, closely resembling it, suffice for maintenance and growth. But zein, the chief protein in Indian corn, which contains neither glycocoll, lysin, nor tryptophane, is only sufficient for maintenance; it did not promote growth. It seems probable, therefore, that tryptophane is absolutely essential for growth, and that without it the animal organism, although it does not lose weight, ceases to grow, and probably its health suffers in other respects. It has been shown above that whole wheat-meal contains more tryptophane than white flour, and that white bread is deficient in this amino-acid.

[1] "Feeding Experiments with Isolated Foodstuffs," by Thomas B. Osborne and Lafayette B. Mendel, Carnegie Institute of Washington, Publication 156, Parts 1 and 2, 1911.

THE RÔLE OF THE LIPOIDS IN METABOLISM.—The principal part of all living cells consist of proteins and lipoids. The living protoplasm is not a homogeneous solution; it is a mixture of substances and solutions only partly miscible with each other. There is a semi-solid substratum of colloidal material, in addition to which are simpler substances, largely in an aqueous solution, but probably partly adsorbed to the colloidal material. It is the oxidation of the substances in solution rather than the colloidal material itself which sets free the energy manifested by the organism. But the colloidal material forms the conditions and supplies the enzymes under whose influence the energy-yielding oxidations and other metabolic processes occur. The colloidal materials are built up by polymerization from substances supplied to the cells—*i.e.*, the amino-acids, fats, and salts in solution. *But the lipoids are necessary to enable most of these substances to enter the cells.* Overton maintains that the outer layer of all cells consists, for the most part, of lipoidal substances, and that only those substances soluble in lipoids can enter the cell; rather the cell wall or plasma membrane is only permeable by substances soluble in lipoids. The best-known lipoids are lecithin, cerebrin, and cholesterin. They are permeable with difficulty by solutions of salt, sugar, and similar substances; but they are easily permeated by substances soluble in fat. The amino-acids are lipoid-solvents, and it is probable they only enter the cells through the lipoidal spaces in the outer layer or plasma membrane of the cells. Meyer says these peculiar lipoids, which intersect and surround the living protoplasm, so to speak, with walls of froth, are of decisive importance in the life and functions of the cells. Internally they prevent a fusion of the innumerable particles of the cell; at the surface they protect it against a too rapid ingress and egress of water, and against invasion by salts and other substances dissolved in the blood and organic fluids. On the other hand, they form a sort of sieve for all the substances soluble in fat, and for those which dissolve in them more readily than in water. Loëb and Beutner[1] consider that the lipoids confer on the cells the property of bio-electrical potentiality; and Lillie[2] has shown that the cells owe the property of irritability, or the power of responding to various stimuli, to the lipoids. The importance of the lipoids in the organic processes of the cells therefore becomes obvious. Moreover, it accords with Schaumann's phosphorus-deficiency theory of beri-beri and other diseases. The lipoids consist of lecithins, cerebrosides, cholesterin, phytosterin, nucleins, etc. Lecithins are widely distributed, but occur especially in milk, egg-yolk, brain, liver, fish-roe, bile, blood, yeast, wheat, maize, and beetroot. Their importance is shown by the fact that the growth of the brain in the mammalian young animal is directly proportionate with the amount of lecithin in its mother's milk. Cholesterin is present in every living cell, but it is especially abundant in milk, eggs, legumes,

[1] *Science*, 1913, 672-673.

[2] *Ibid.*, 967.

carrots, beetroots, cereals, and nerve tissues. Nuclein is a generic name for a large number of organic phosphorus compounds in animal and vegetable cells, particularly in nuclei. Muscular tissue contains allied bodies called *nucleons*; phosphocarnic acid in muscle juice is an example. These phosphorized bodies are therefore very important, and there are no substances which the organism stores more carefully. But it is probable the higher animals are not endowed with the power to manufacture these organic phosphorus compounds, or to transform organic phosphorus compounds from one group into another group. They must be derived from the food. An attempt was made by Stepp[1] to throw light on the subject; he fed mice on foods from which the lipoids had been extracted. He compared the duration of life on ordinary food, lipoid-free food, and lipoid-free food to which lipoids were added. The conclusion arrived at was that mice could not be kept alive on lipoid-free food. It was suggested that the vital element was fat, and, in the case of milk, that butter-fat was the vital element. But Stepp found that the addition of butter-fat to the lipoid-free diet did not supply the missing essential element. But an extract of skimmed or fat-free milk added to lipoid-free food restored the mice to health and vigour. Kossell showed that the yolk of hens' eggs contains no preformed *nucleinic acid*, but is rich in lecithin; but after fertilization there is a rapid synthesis of nuclear materials at the expense of the lecithin, and it may be supposed, as the lecithin disappears, it is utilized in the synthesis of nuclein. Cholesterol is strictly conserved in the organism, and observations were made by Gardner and Lauder[2] to determine whether it is synthetized in the organism. They experimented on rabbits and chickens, and concluded that the cholesterol content of the blood of rabbits and chickens depends on the proportion of cholesterol in their food, and there is nothing to indicate that the growing organism can synthetize cholesterol. During inanition the blood of animals contains an increased amount of cholesterol, both free and combined, drawn from the tissues to meet the demands of the organism for this important substance. If, therefore, the organism is unable to synthetize phosphorus-containing organic compounds, and the organism needs a daily supply of these substances, the food which does not contain an adequate proportion of lipoidal materials is deficient in important and vital constituents, and the organism necessarily suffers. This, however, while supporting Schaumann's phosphorus-deficiency theory, is by no means against the vitamine theory; for it is extremely probable that vitamines can only enter the cells when adsorbed to a lipoid, or locked up in a lipoidal compound.

THE RÔLE OF THE INORGANIC SALTS.—Feeding experiments continued for more than a few days demonstrate the absolute necessity for the inclusion of a proper proportion of salts in the daily diet.

[1] *Biochem. Zeit.*, 1909, xxii. 452; and *Zeit. f. Biol.*, 1911, lvii. 135.
[2] Proc. Roy. Soc., May, 1912, 391; and January, 1914, 229.

But the study of the use and application of salts in the body has only just begun. The ash of milk, meat, vegetables, and bread can be imitated; but observations show that artificial mixtures of mineral salts are very different in effect from the combinations prevailing in the foods, the blood, and tissues. Osborne[1] says: "The balance of acid and basic groups, the changing need for individual elements like phosphorus, calcium, chlorine, and iron, furnish a series of complex variables which are probably as indispensable to certain aspects of nutrition as they are unappreciated." The reason why an animal cannot live on ash-free diet is not clear. But Loëb[2] believed he found an important use for the salts. He says the cells of our body live longest in liquids containing molecules of salts in the following proportion: 100 NaCl, 2·2 KCl, and 1·5 $CaCl_2$. "The rôle played by these salts appears to be that of 'tanning' the surface film of the cells, and thus conferring on them the important qualities of physical durability and comparative impermeability, without which they cannot exist."[3] Thus the neutral salts NaCl, KCl, and $CaCl_2$ are essential to the preservation of animal life, although they do not furnish the body with energy.

It has long been a question whether living cells are permeable to salts in solution. Nobody denies that substances in solution diffuse into the cells more slowly than water. But Overton and Hoebner deny that inorganic salts can diffuse into the cells at all. Lillie[4] says each cell may be likened to a chemical factory in which work can only go on properly when diffusion through the cell wall is restricted, and the rate of diffusion through the cell wall (outer layer or plasma membrane) depends on the permeability of its substance. According to Overton, the substance of the outer layer or plasma membrane consists mainly of lipoids. Substances soluble in lipoids readily pass through the lipoidal partitions of the outer layer or cell membrane, and therefore the cell is permeable by that class of materials. But it has been shown by Lillie that this permeability is variable, and alterable by various substances. Sodium salts, though essential, are toxic to the cells; they increase the permeability and irritability of the outer layer or plasma membrane. Magnesium and calcium salts have the reverse effect. Magnesium chloride renders the plasma membrane resistant to the permeability-increasing and cytolytic action of sodium chloride, and at the same time render the irritable elements resistant to stimulation. This alteration of the outer layer of the cells or plasma-membrane by salts is produced by changing the general condition of the colloids forming it, or by altering the state of the lipoidal components. When a substance soluble in lipoids acts on the outer layer of the cell or plasma-membrane, or dissolves in the the lipoids of the latter, it may profoundly change the physical proper-

1 *Science*, 1911, 725.
2 *Ibid.*, 1911, 655.
3 *Ibid.*, 653.
4 *Ibid.*, 1913, 972.

ties of the membrane and the responsiveness of the whole cell to stimulation. Changing the state of the cell membrane may alter the whole physiological activity of the cell, and of the organ which such cells compose. Thus the influence of the salts is of great importance. Certain salts are necessary for the solution of the proteins; others are necessary to harden the lipoidal constituents of the cell membrane or the outer layer of the cell. The lipoids also essential to the organism are probably not vitamines, nor are they amino-acids, but they are essential for the admission of the vitamines into the interior of the cells.

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